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Coastal Ocean Models as Planning Tools

A Case Study from Hurricane Katrina Storm Surge

Dr. Cheryl Ann Blain
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Naval Research Laboratory
Stennis Space Center, MS

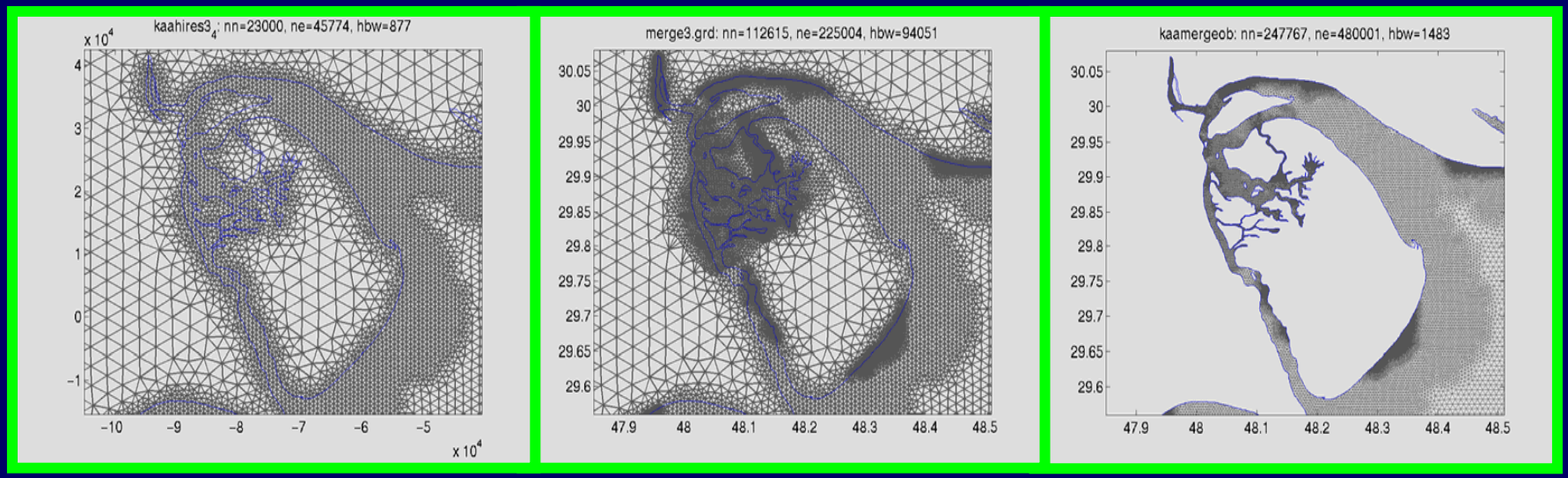
blain@nrlssc.navy.mil

Why Would the Navy be Interested in Storm Surge?

- Impact on Operations
- Protection of Assets
- Interest in the fate of enemy assets

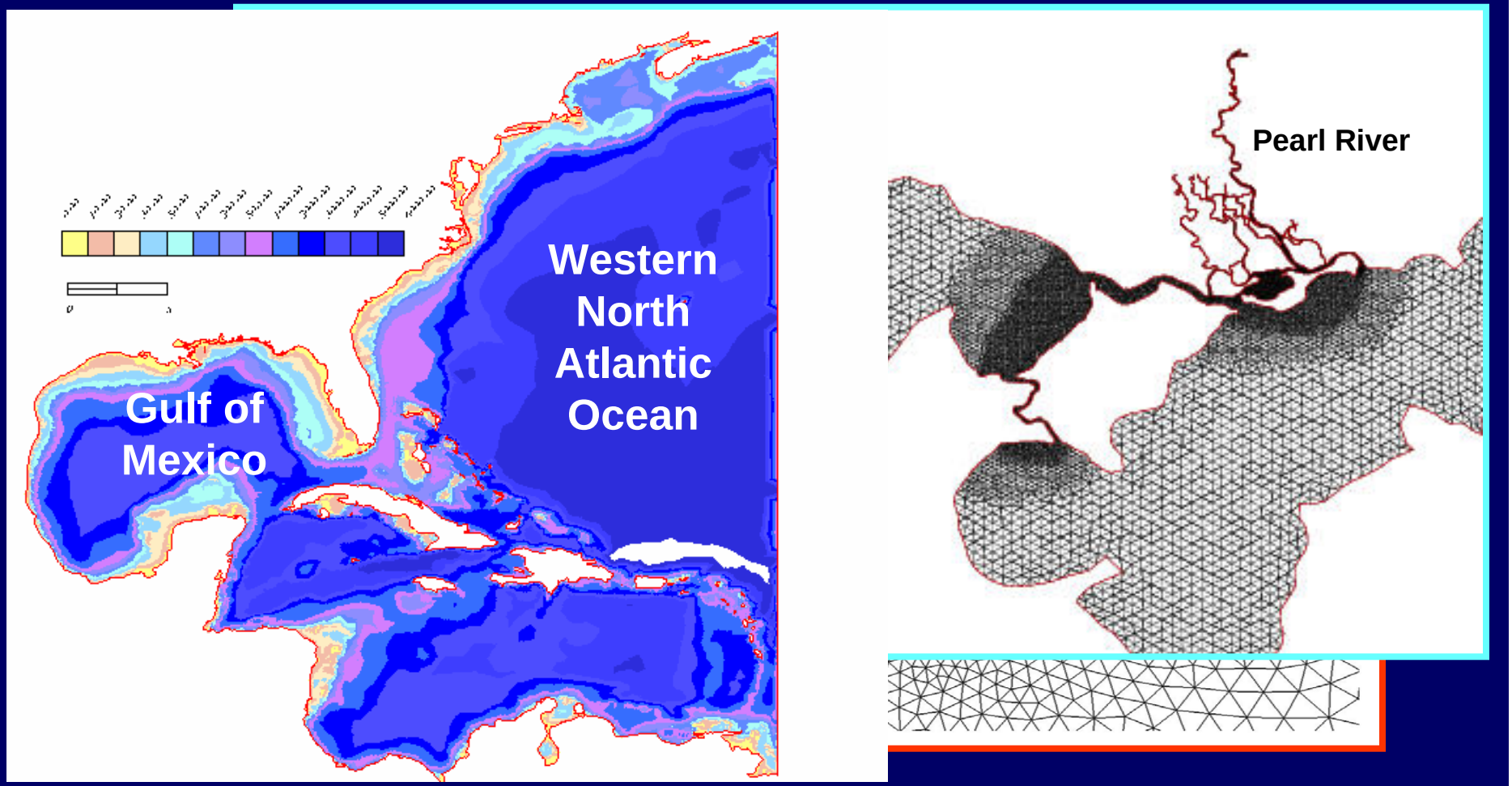
Katrina Provided An Opportunity to Evaluate Navy Prediction Systems

- Typical applications in denied areas – sparse data
- Rapid deployment a priority – automation of modeling
- Require robust, accurate forecasts



Development of semi-automated mesh generation

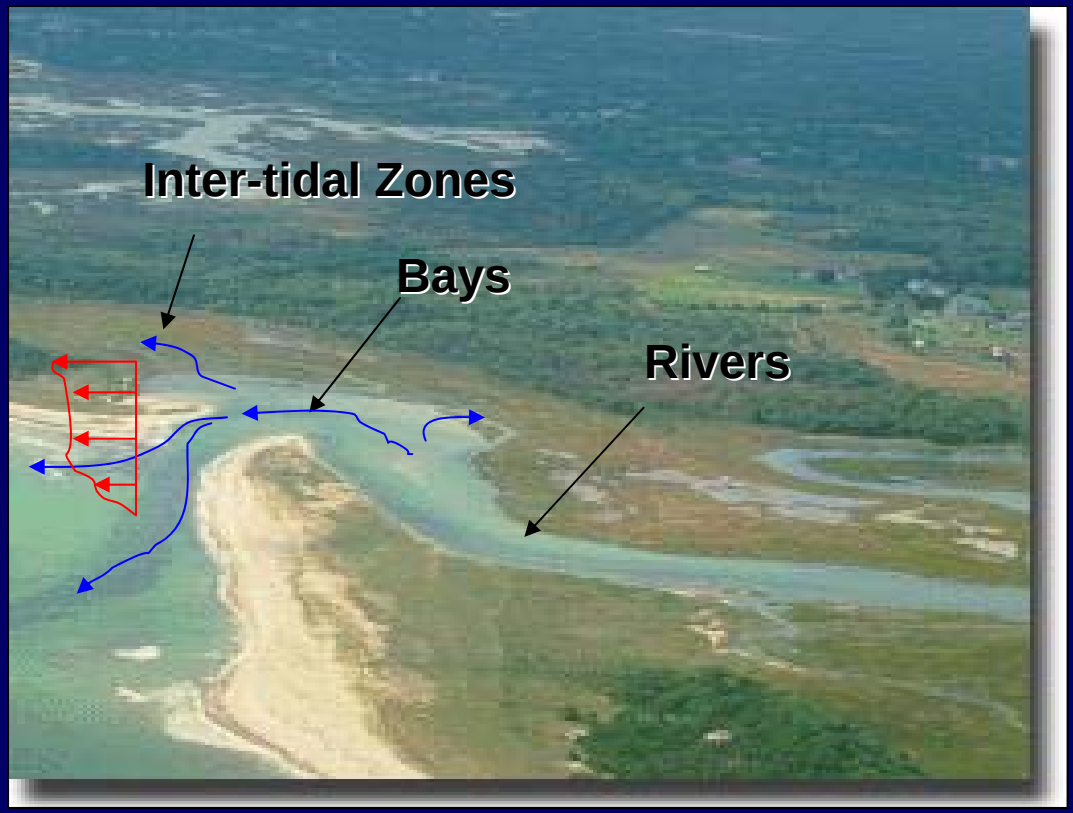
Approach: Unstructured Grids



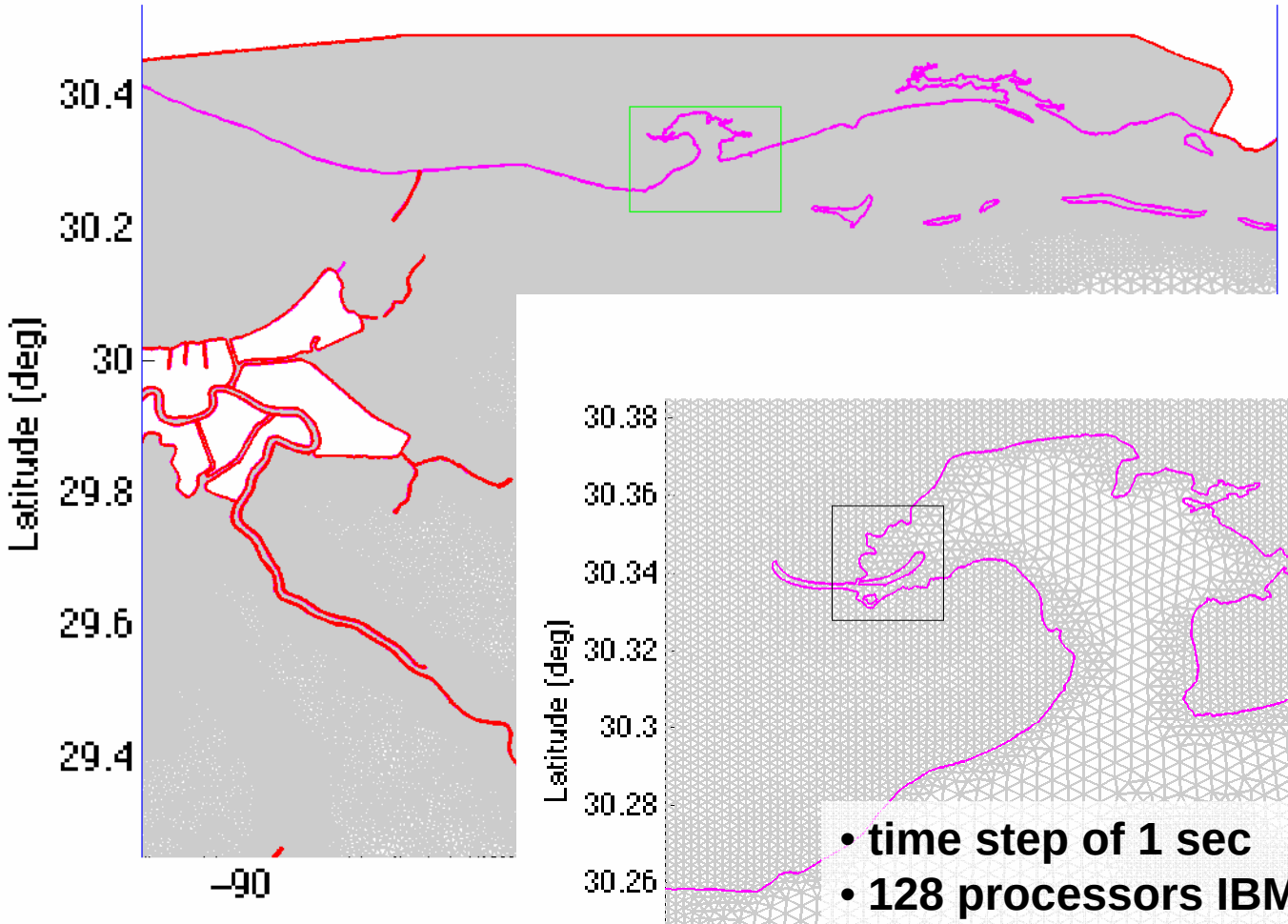
- Realistic coastline morphology
- Fine-scale resolution of inter-tidal zones, rivers
- Large domains with remote open boundaries

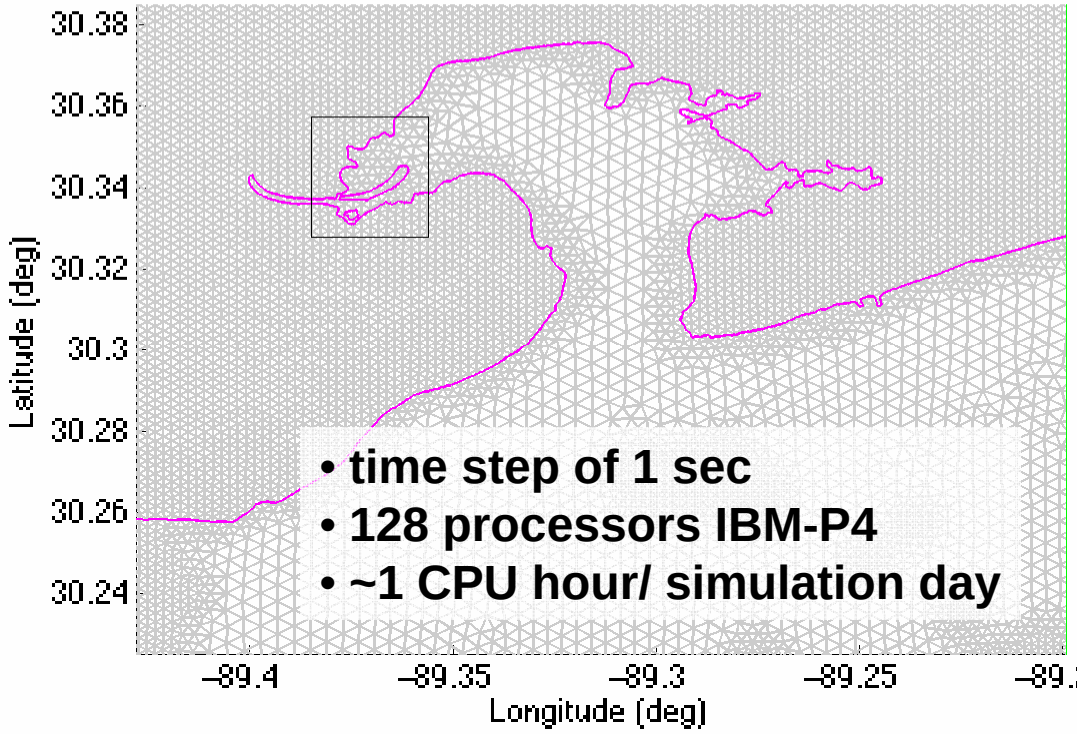
Coastal Ocean Model

Advanced Circulation Model for Shelves, Coasts and Estuaries (ADCIRC)



- 3D dynamics
- Forcing from tides and wind (waves, rivers)
- Shoreline inundation/recession
- Utilizes unstructured grids (finite elements)
- MPI parallelization





- time step of 1 sec
- 128 processors IBM-P4
- ~1 CPU hour/ simulation day

No. elements = 730,431
No. nodes = 375,479

Hurricane Winds

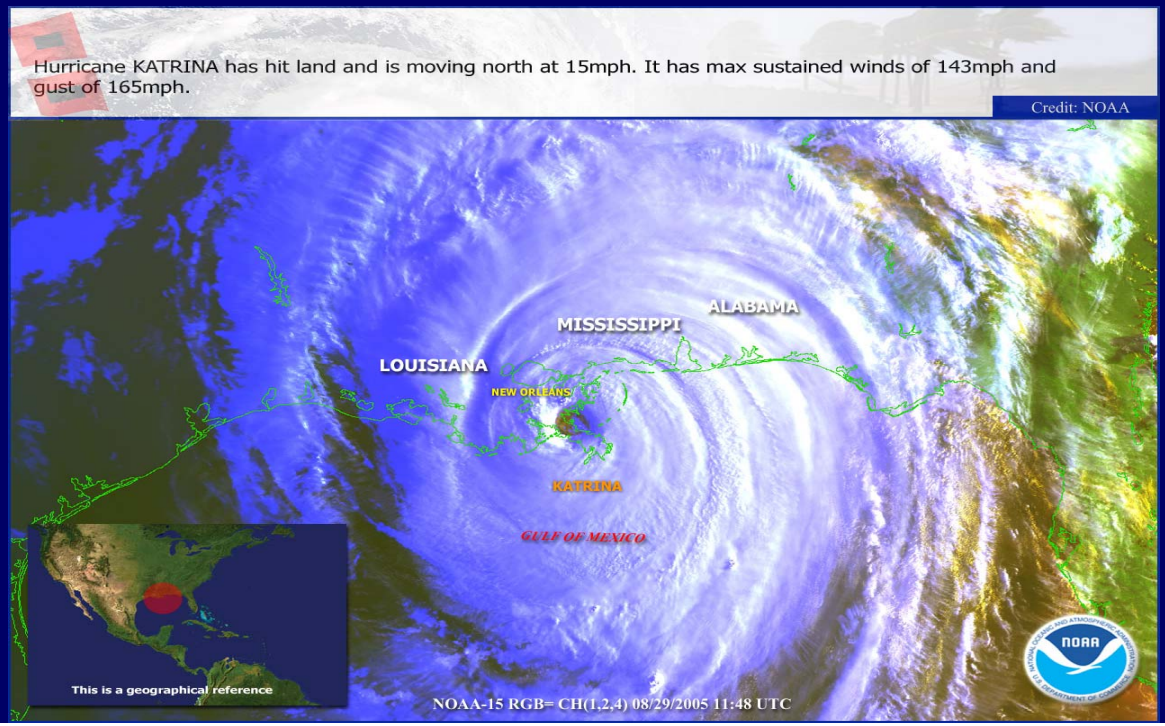
NOAA HRD H*Wind Reanalysis

www.aoml.noaa.gov/hrd/Storm_pages/katrina2005/wind.html

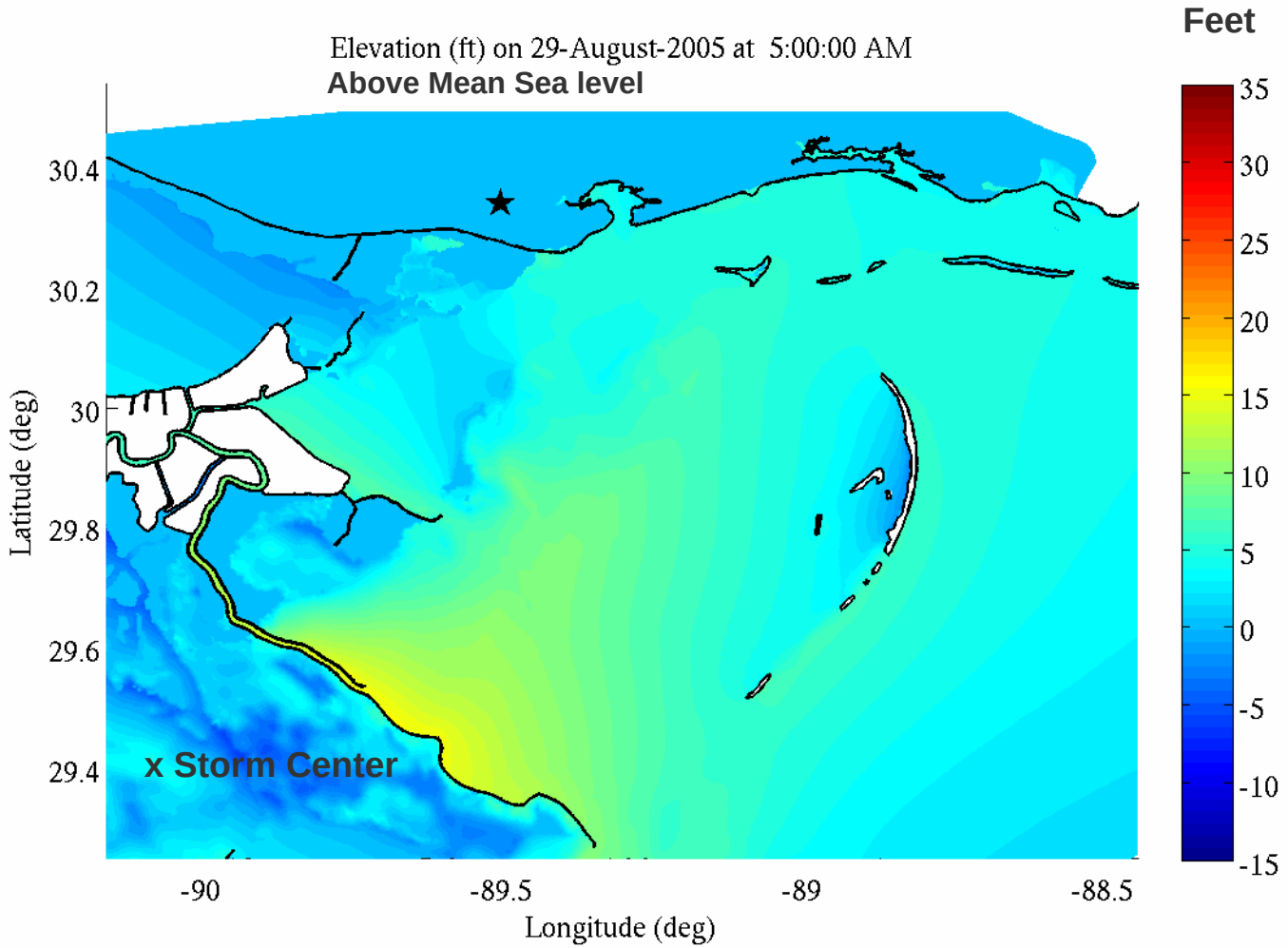
28 Aug 1800 UTC – 30 Aug 1000 UTC

Lagrangian interpolation to 15-minute intervals

Garratt surface wind drag parameterization



ADCIRC Computed Tides + Surge



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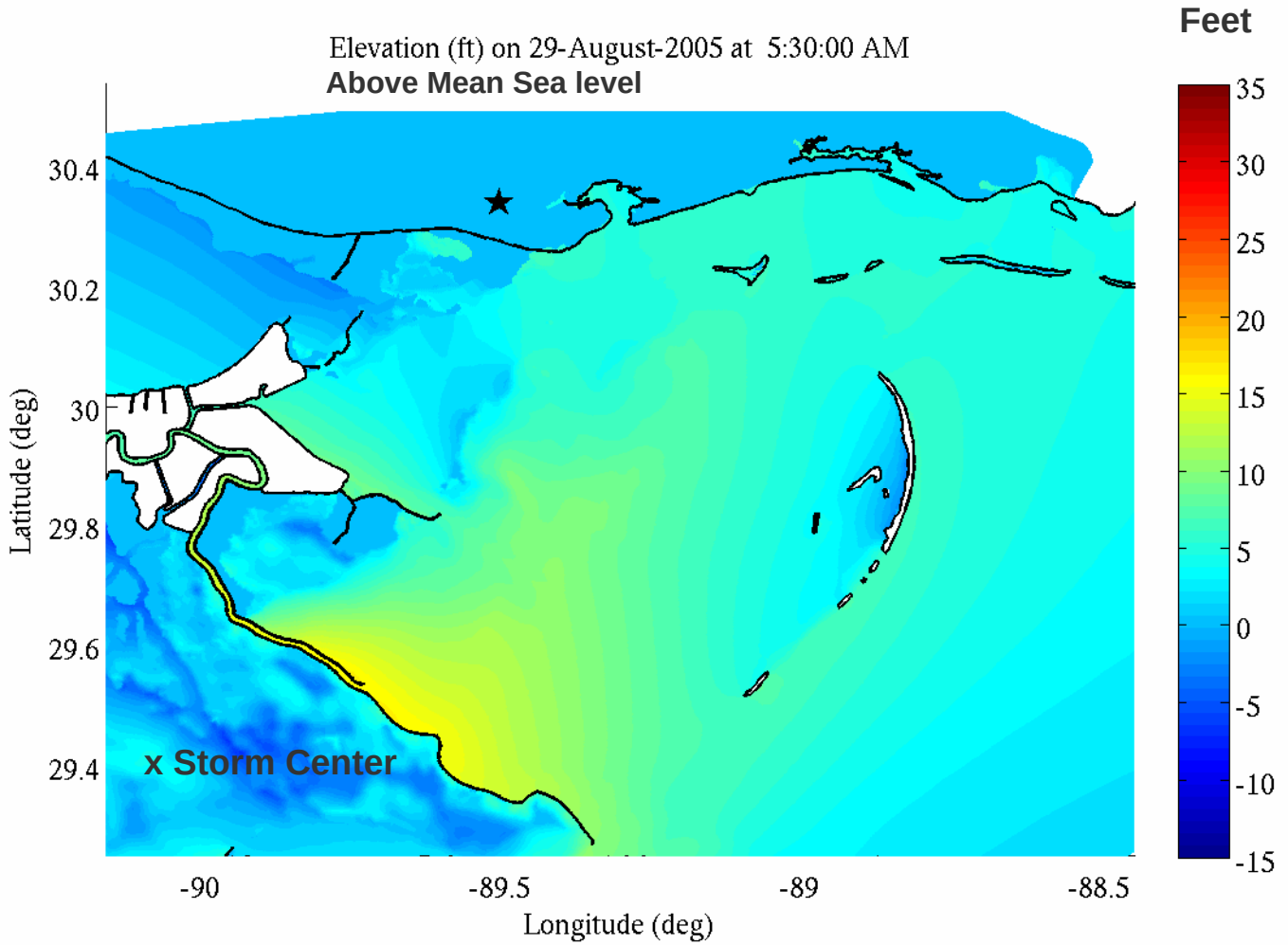

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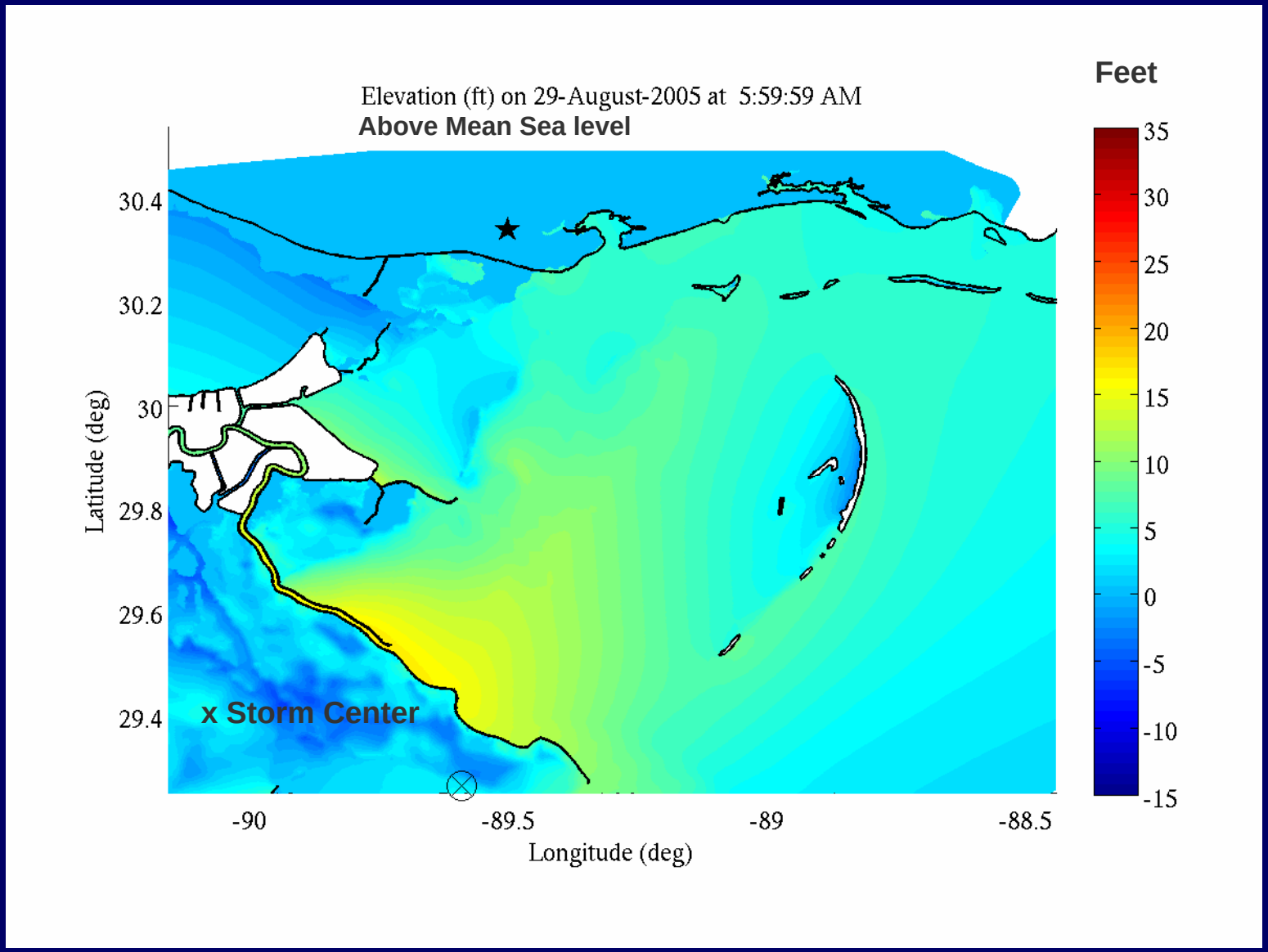

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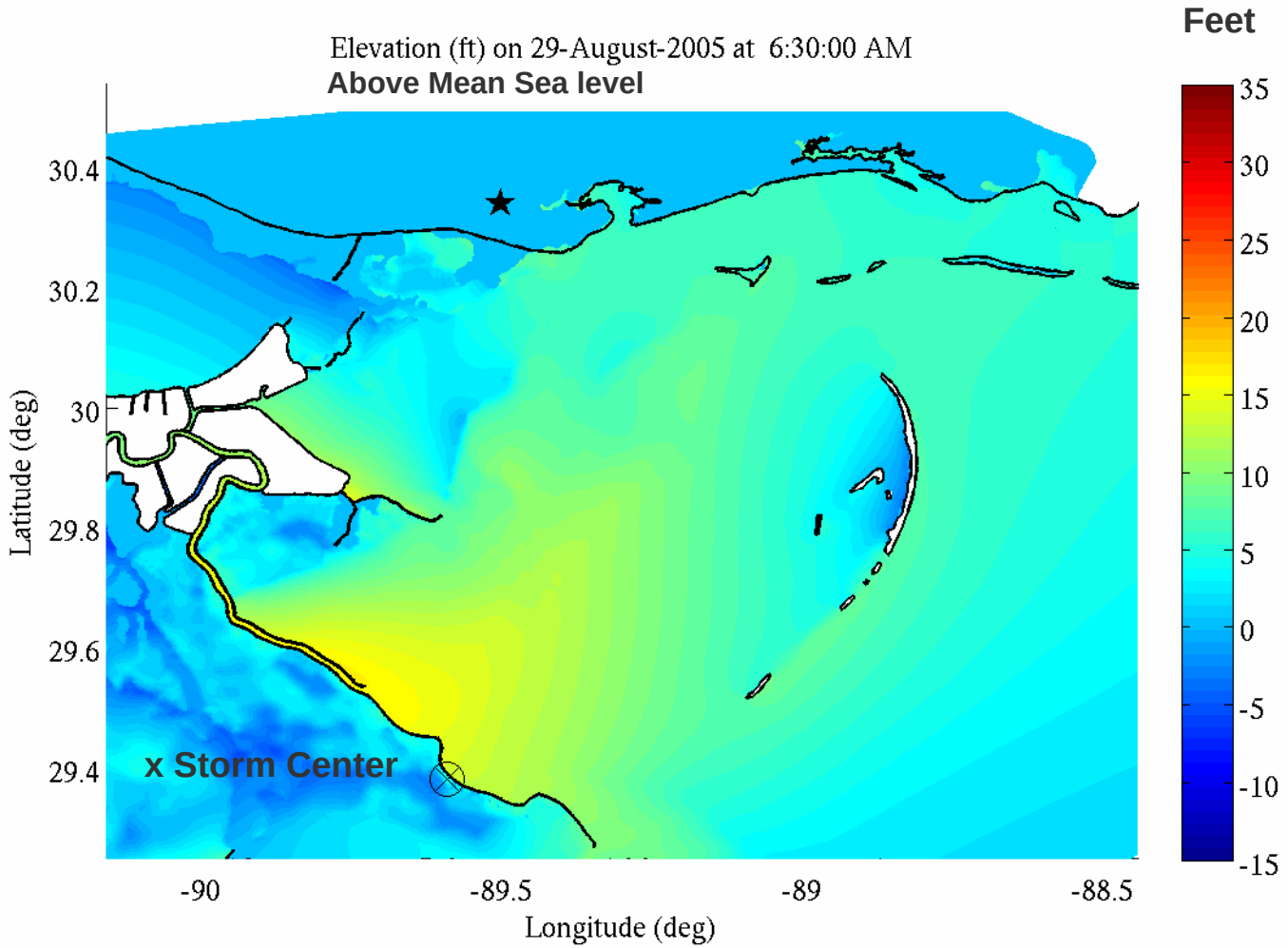

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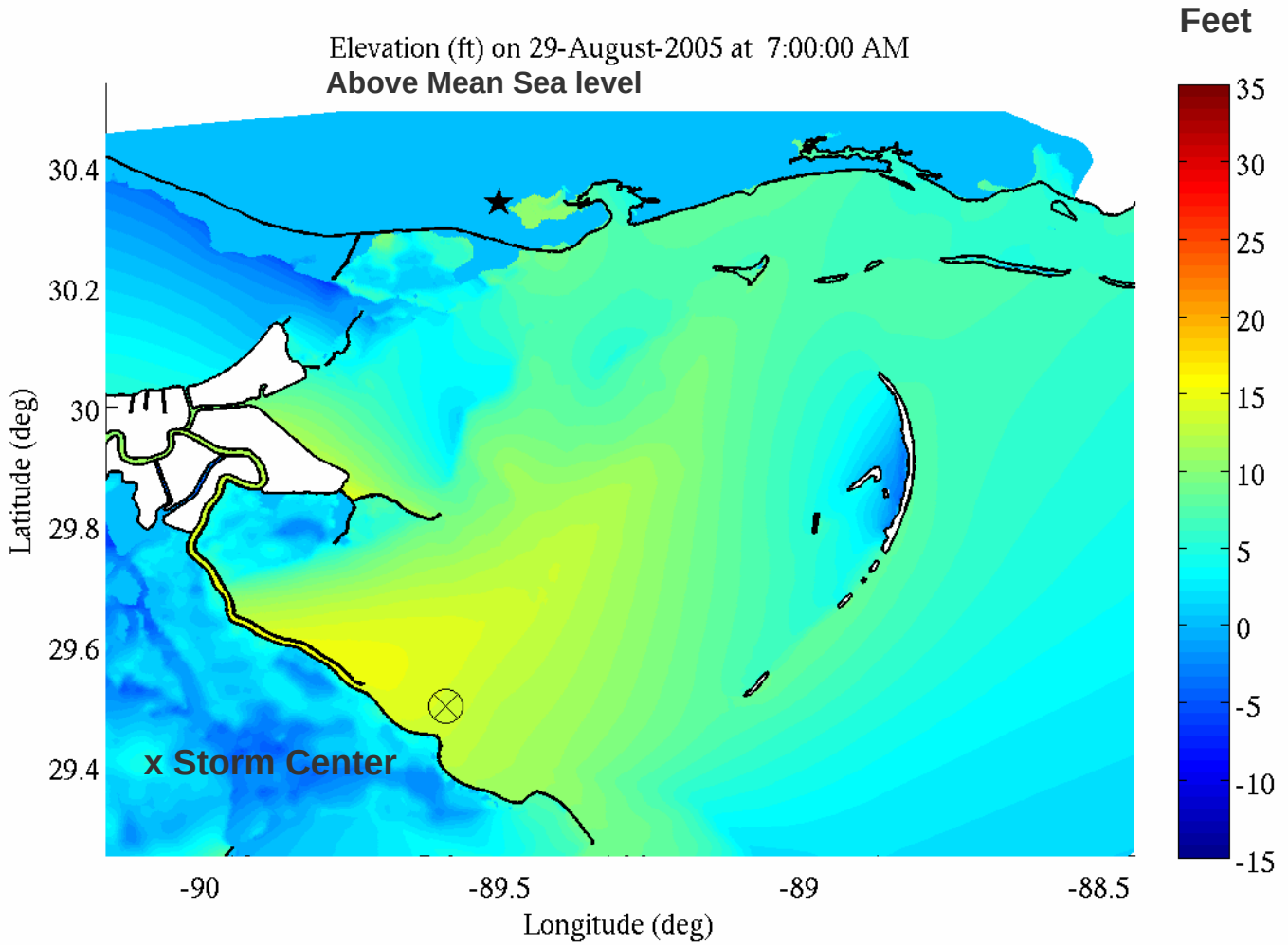

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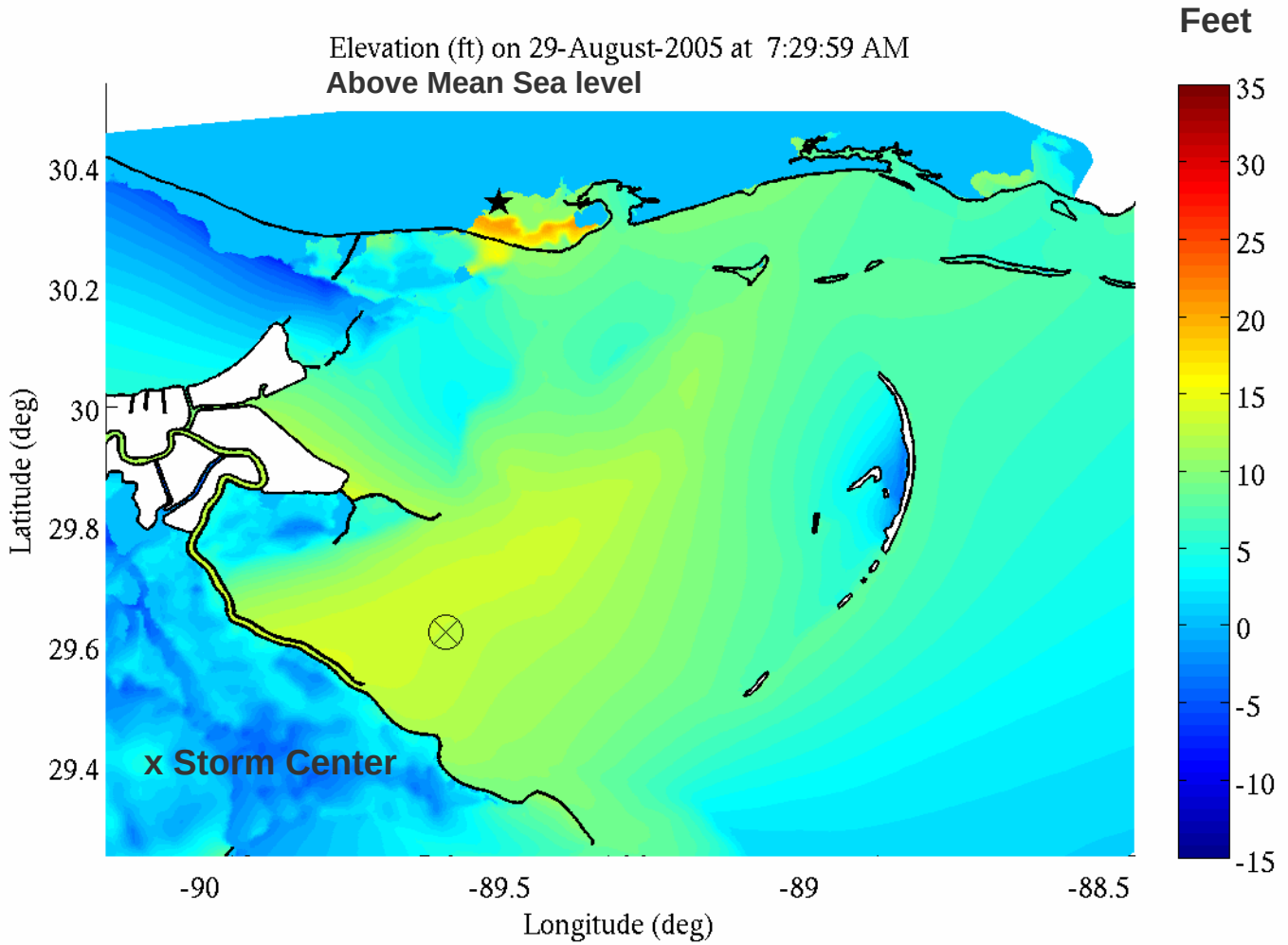

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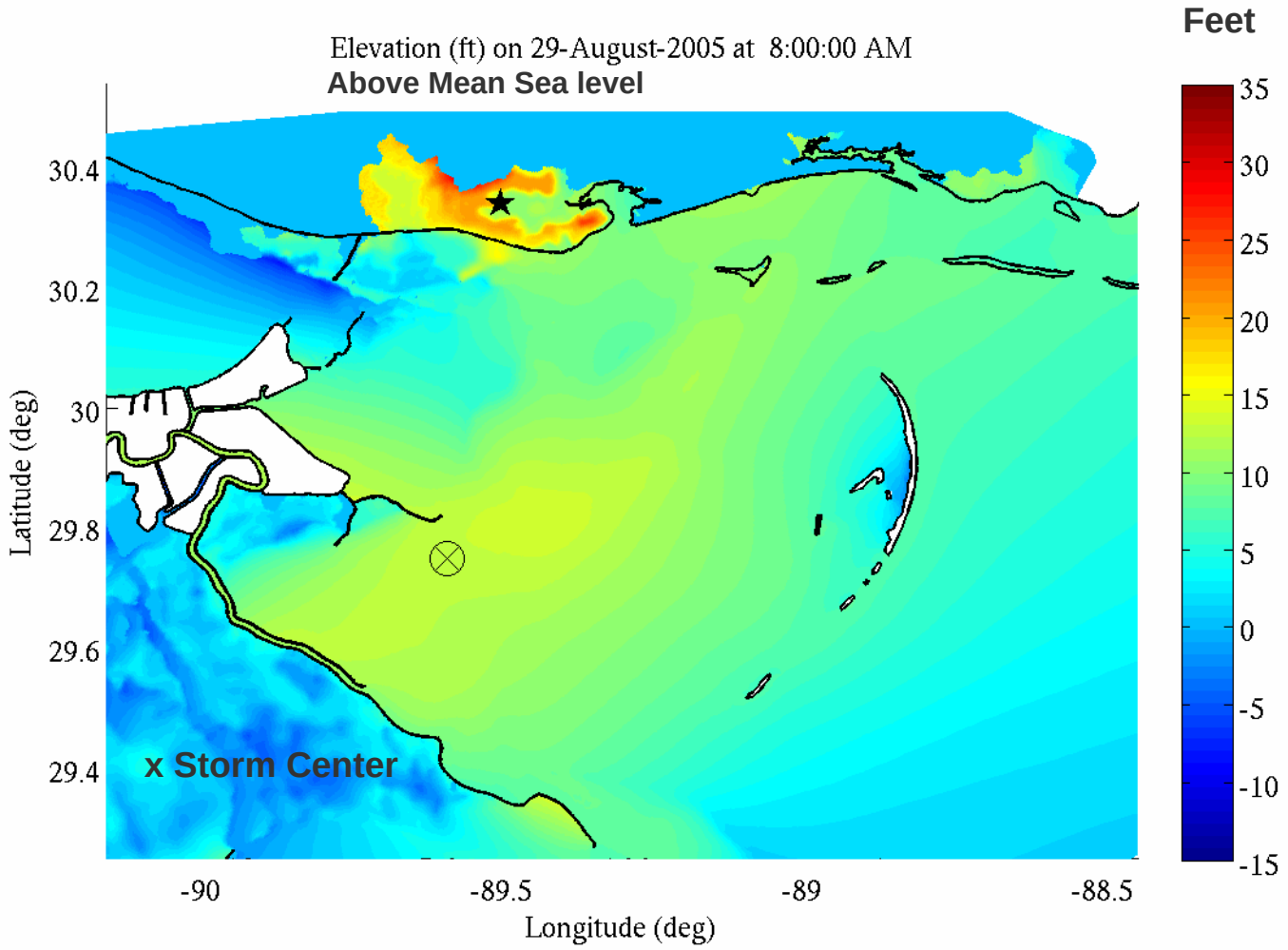

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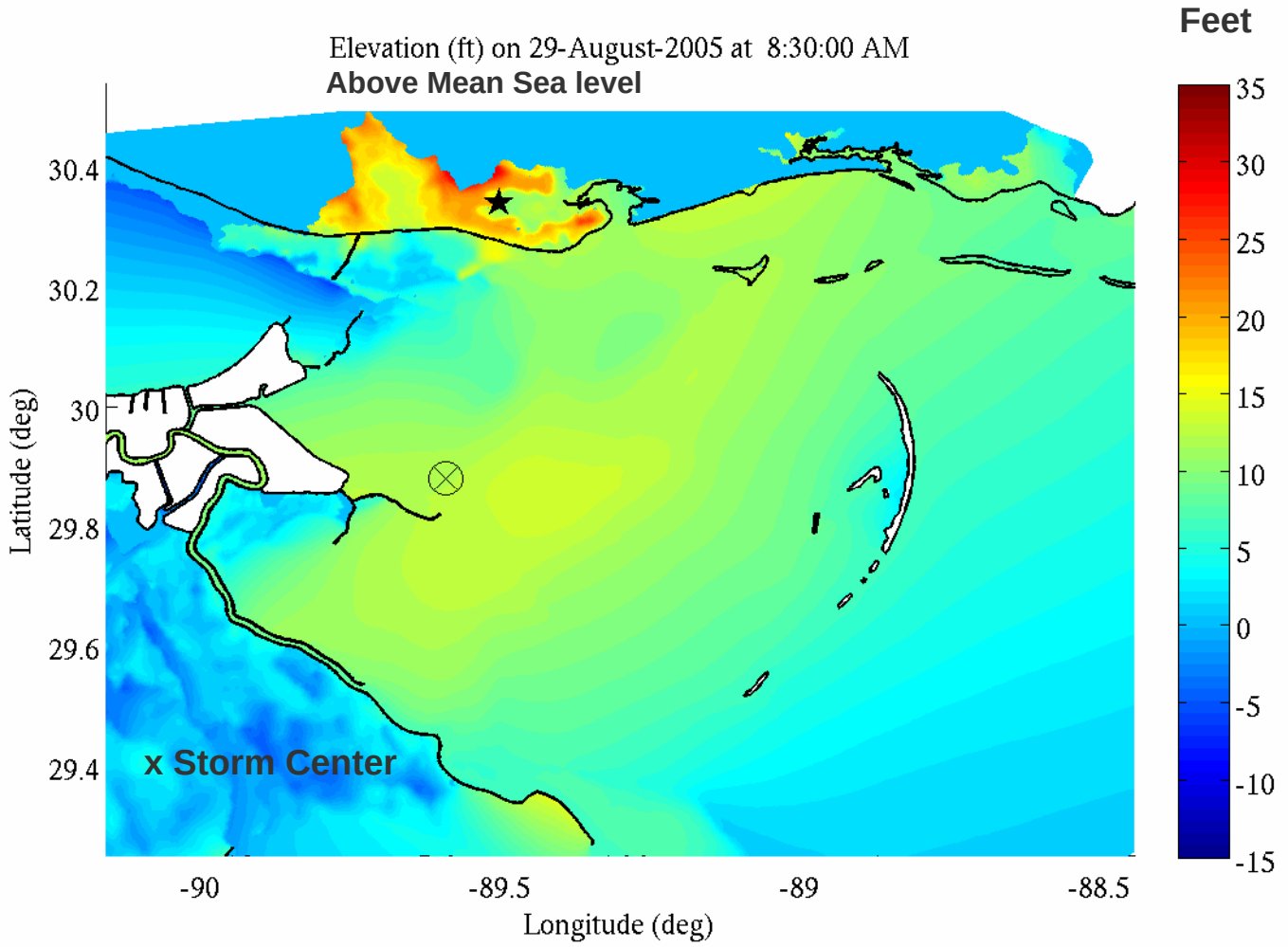

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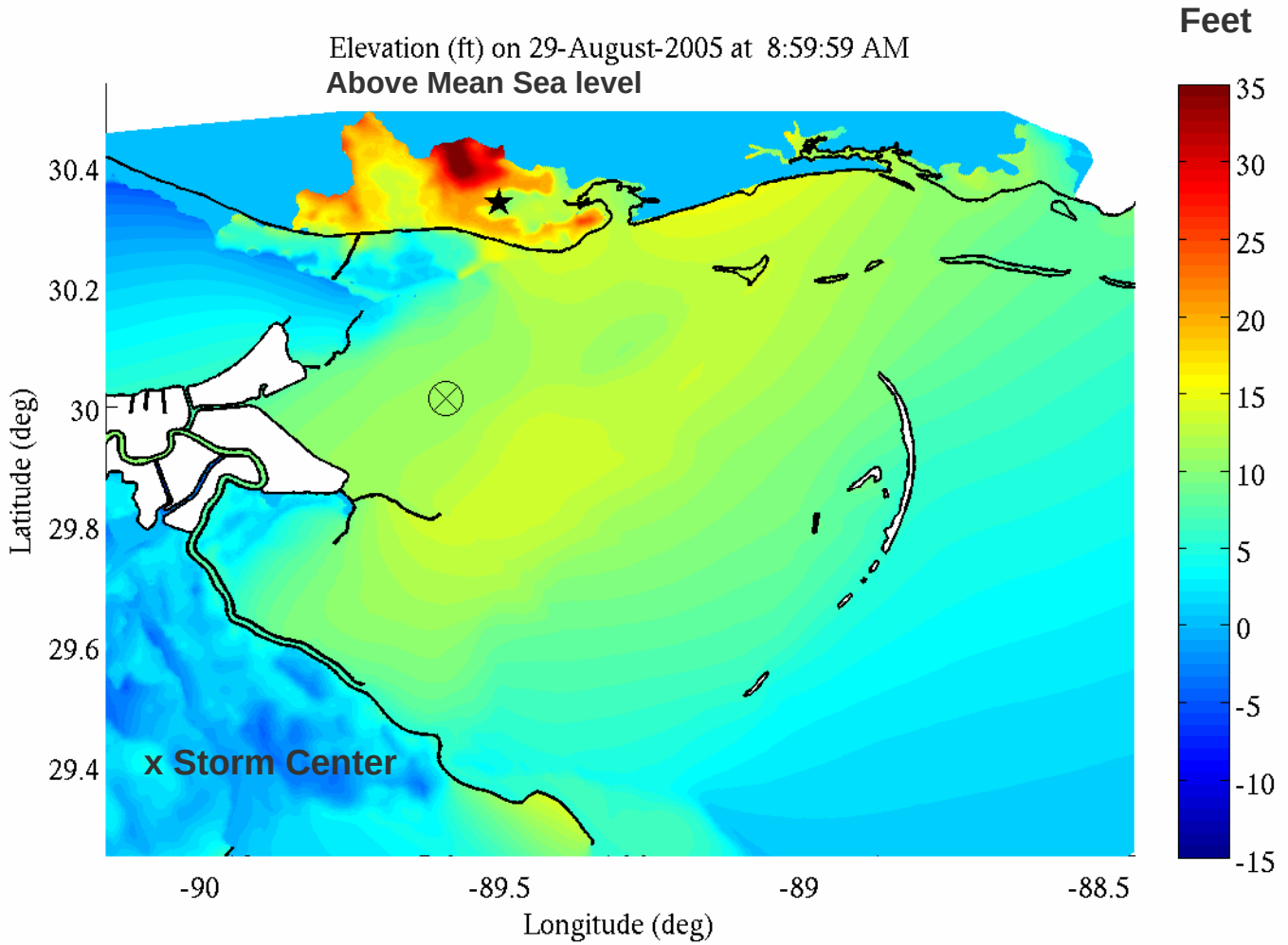

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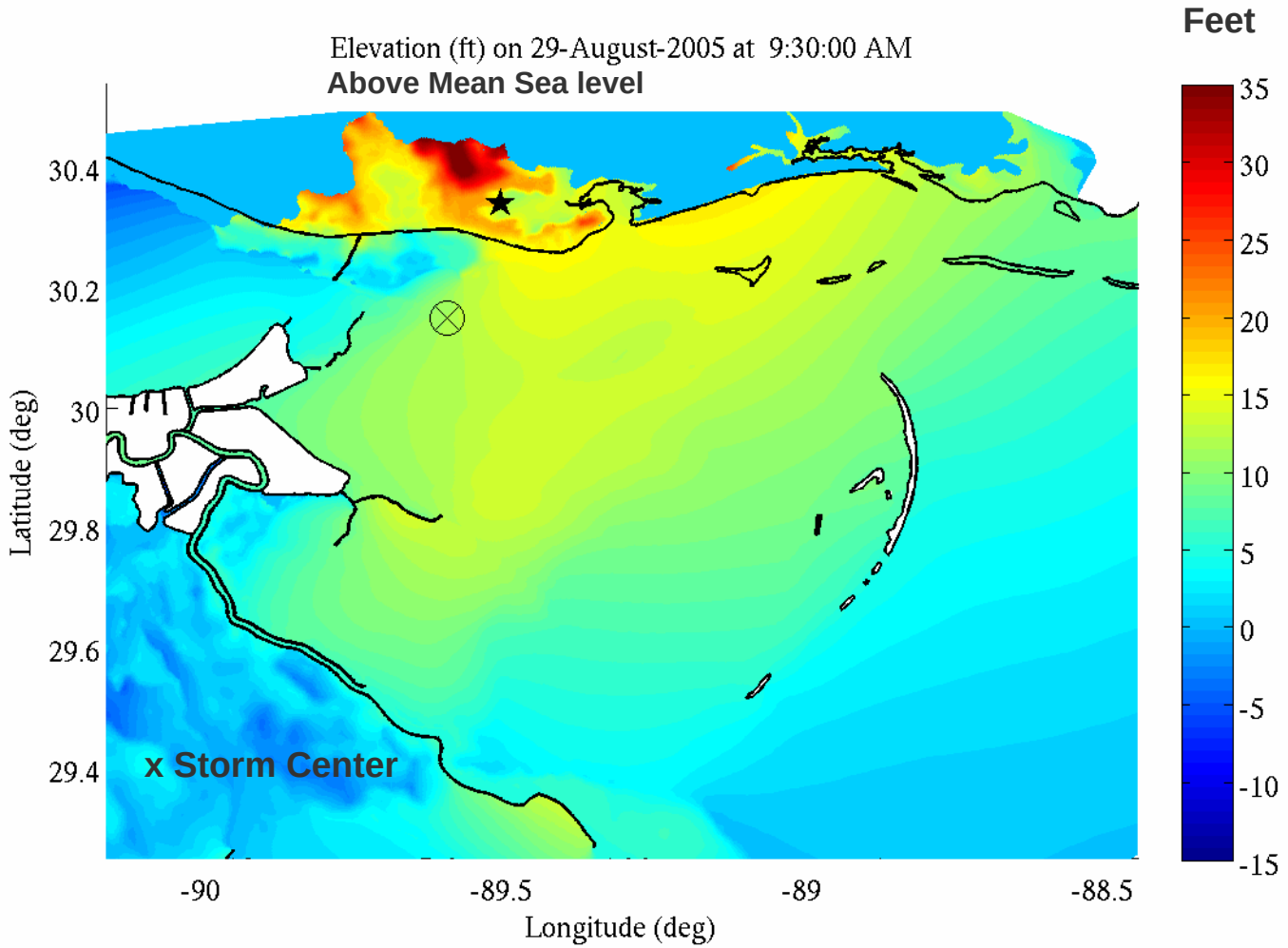

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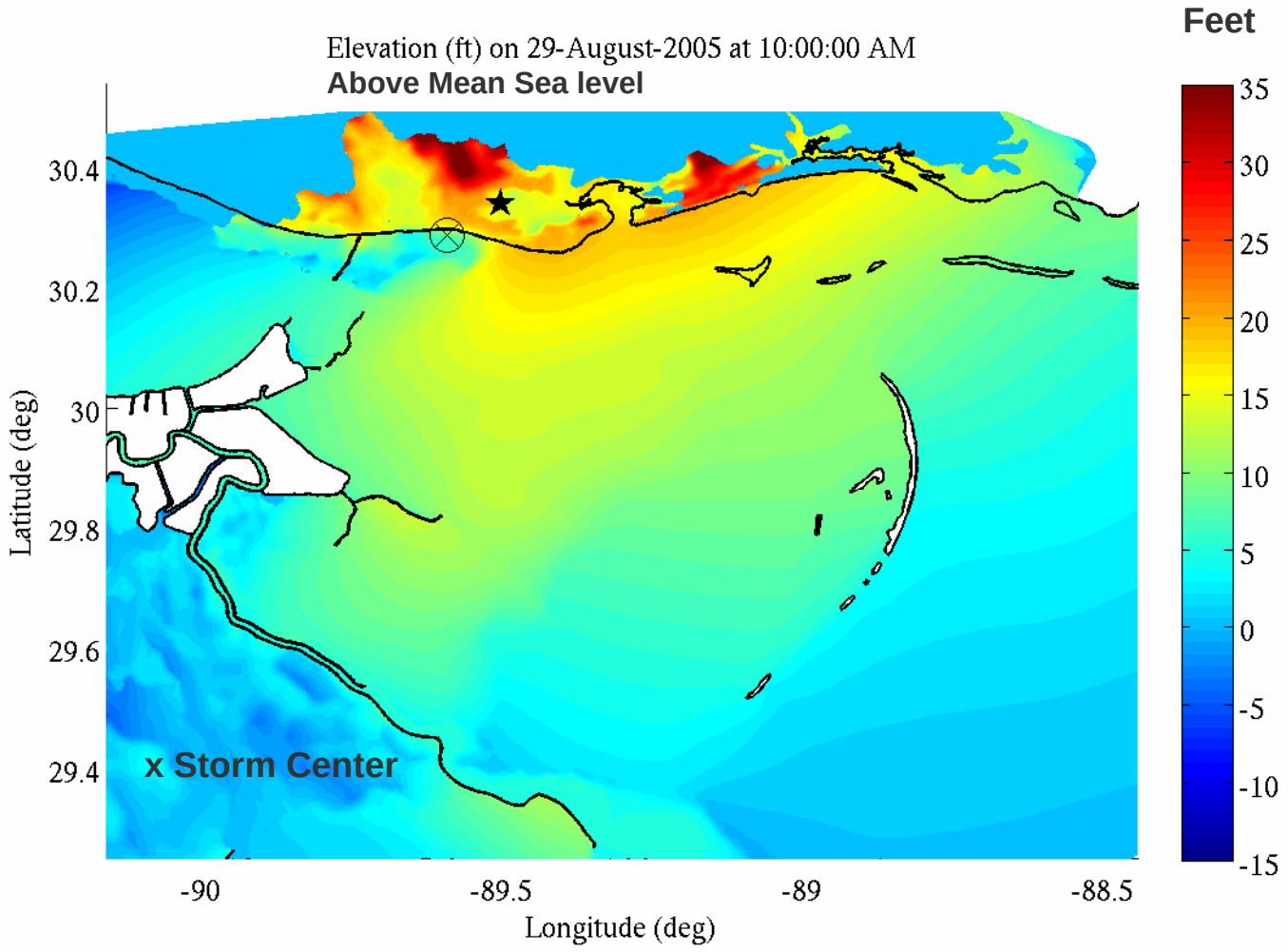

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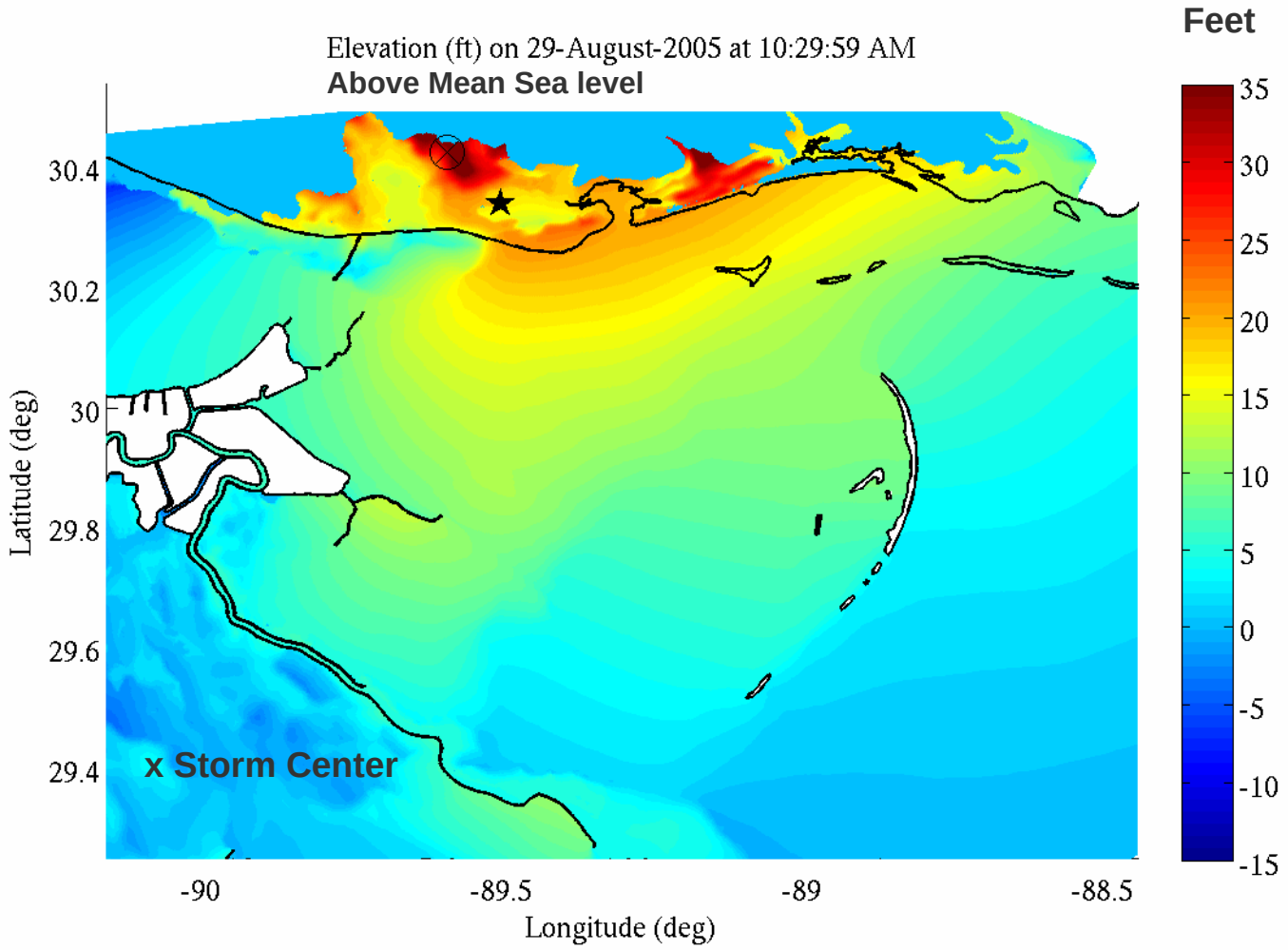

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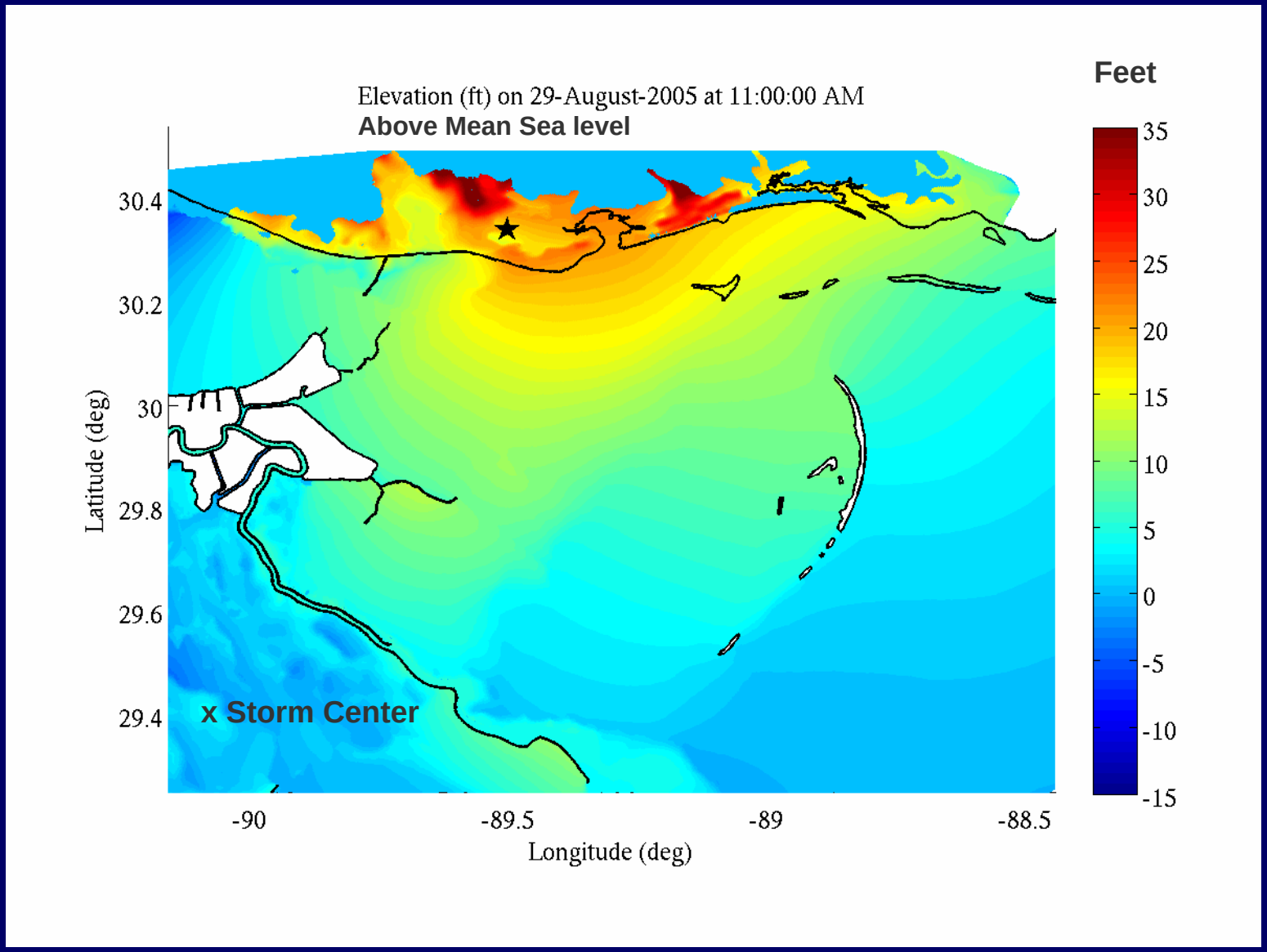

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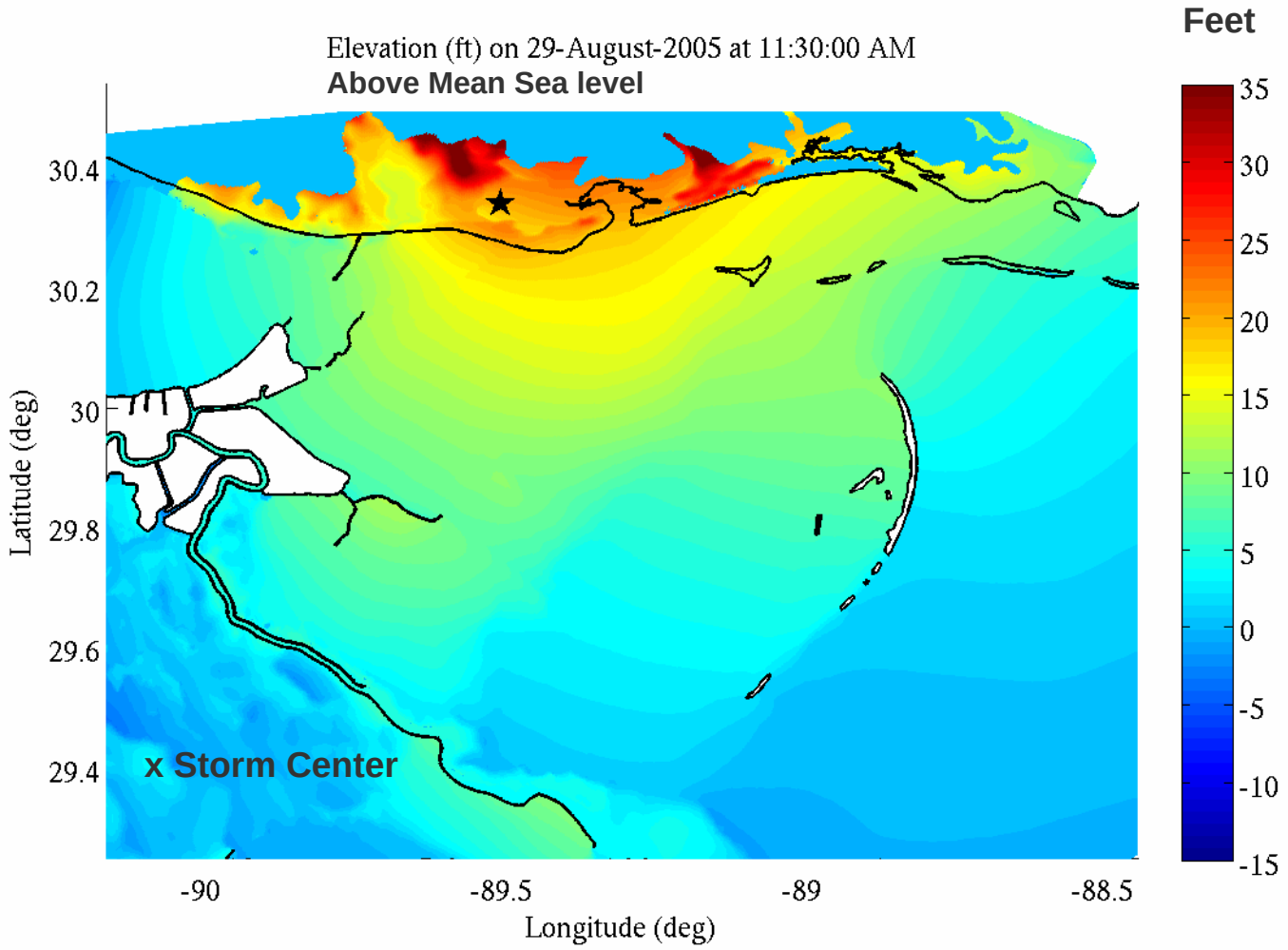

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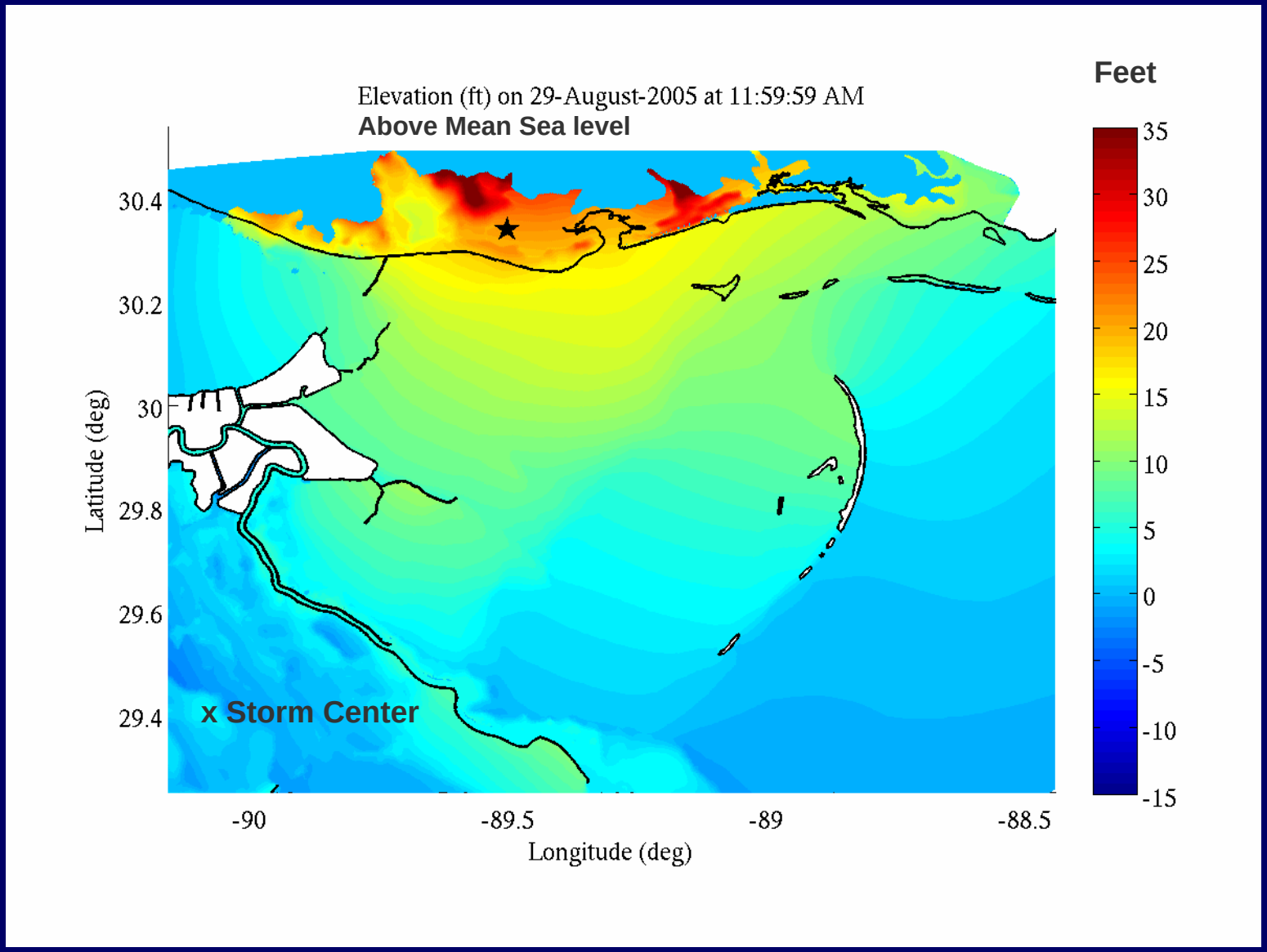
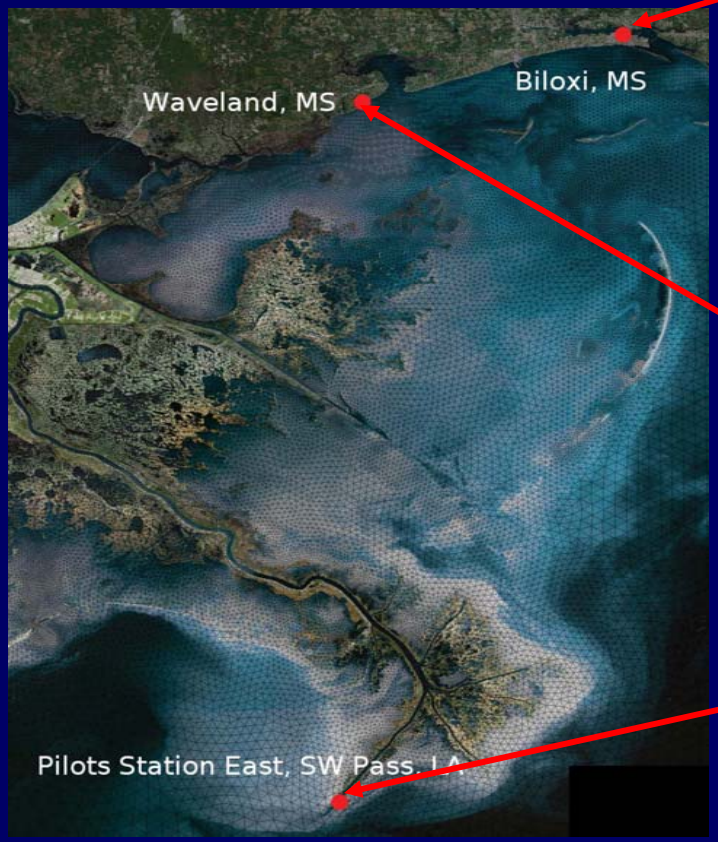
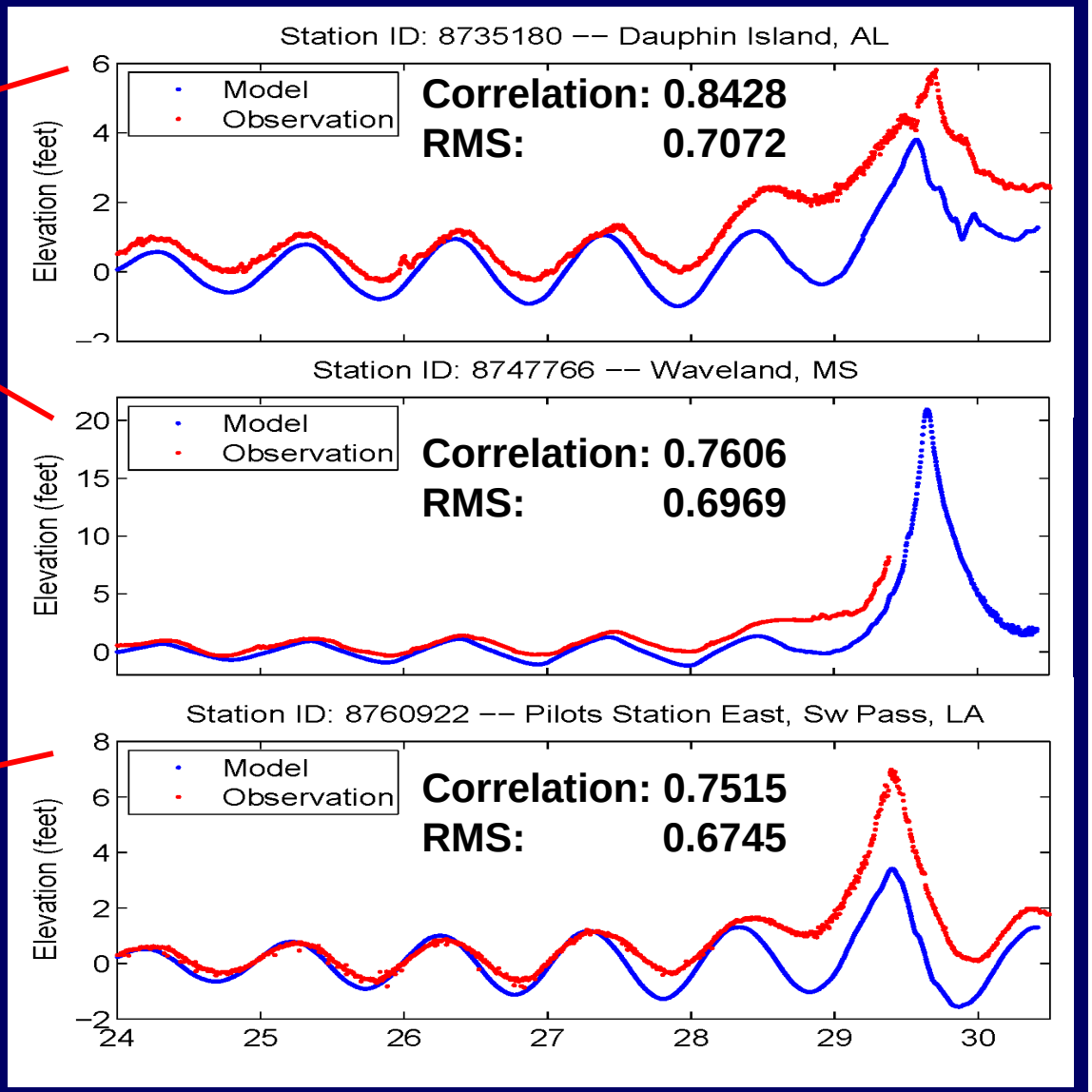


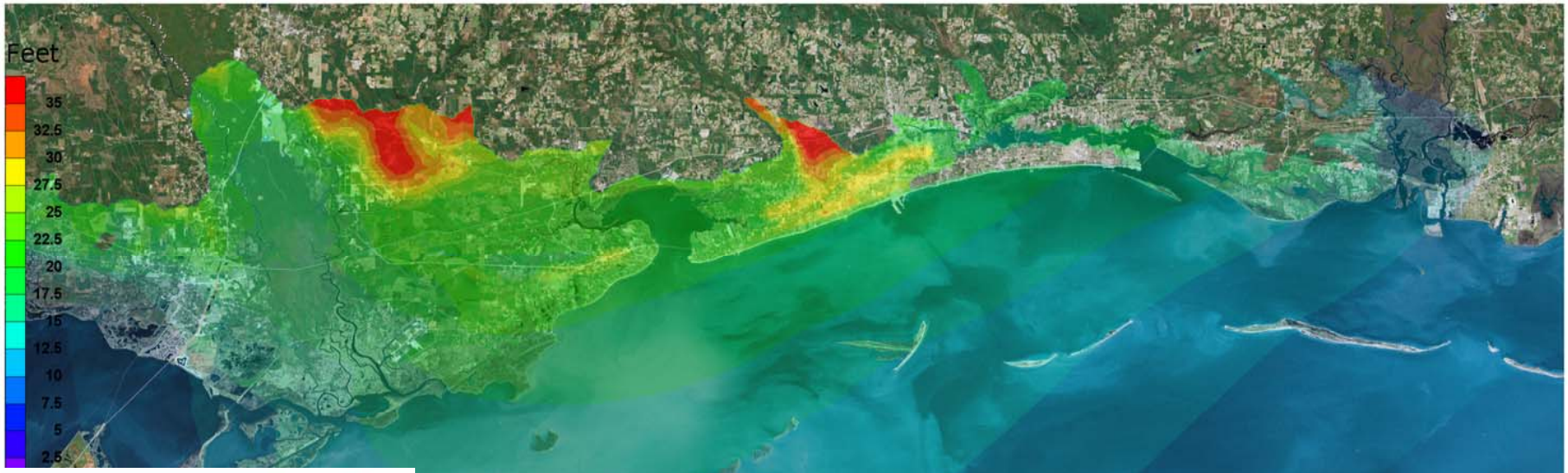
Water Level Comparisons

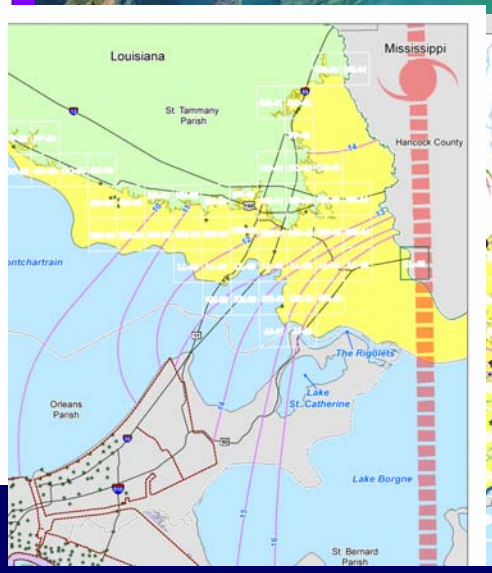




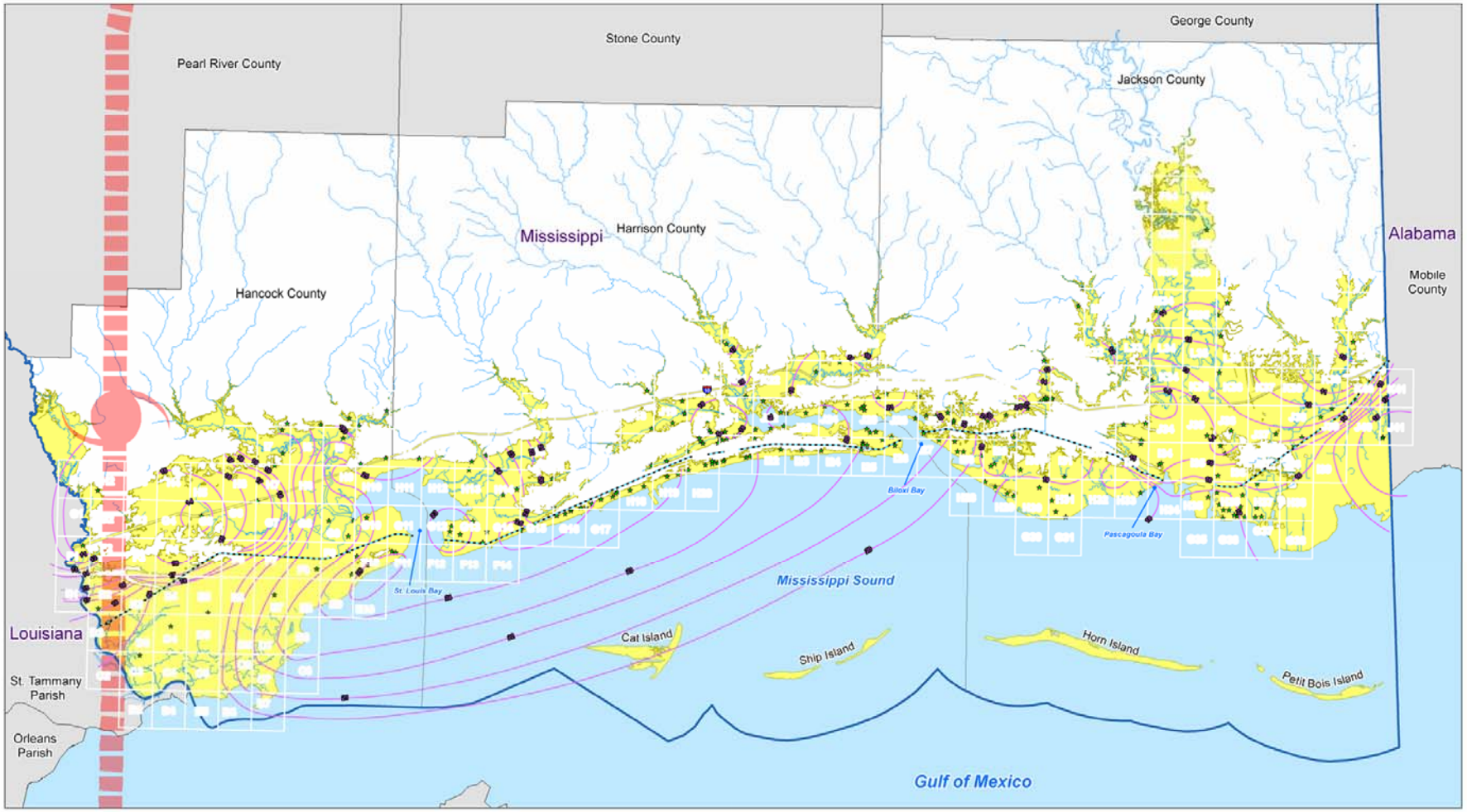
Surge Inundation Map

ADCIRC Model





FEMA Map



Mississippi Hurricane Katrina Surge Inundation and Advisory Base Flood Elevation Map Panel Overview

Date of Event: August 29, 2005; Date of Map: November 2005

FEMA

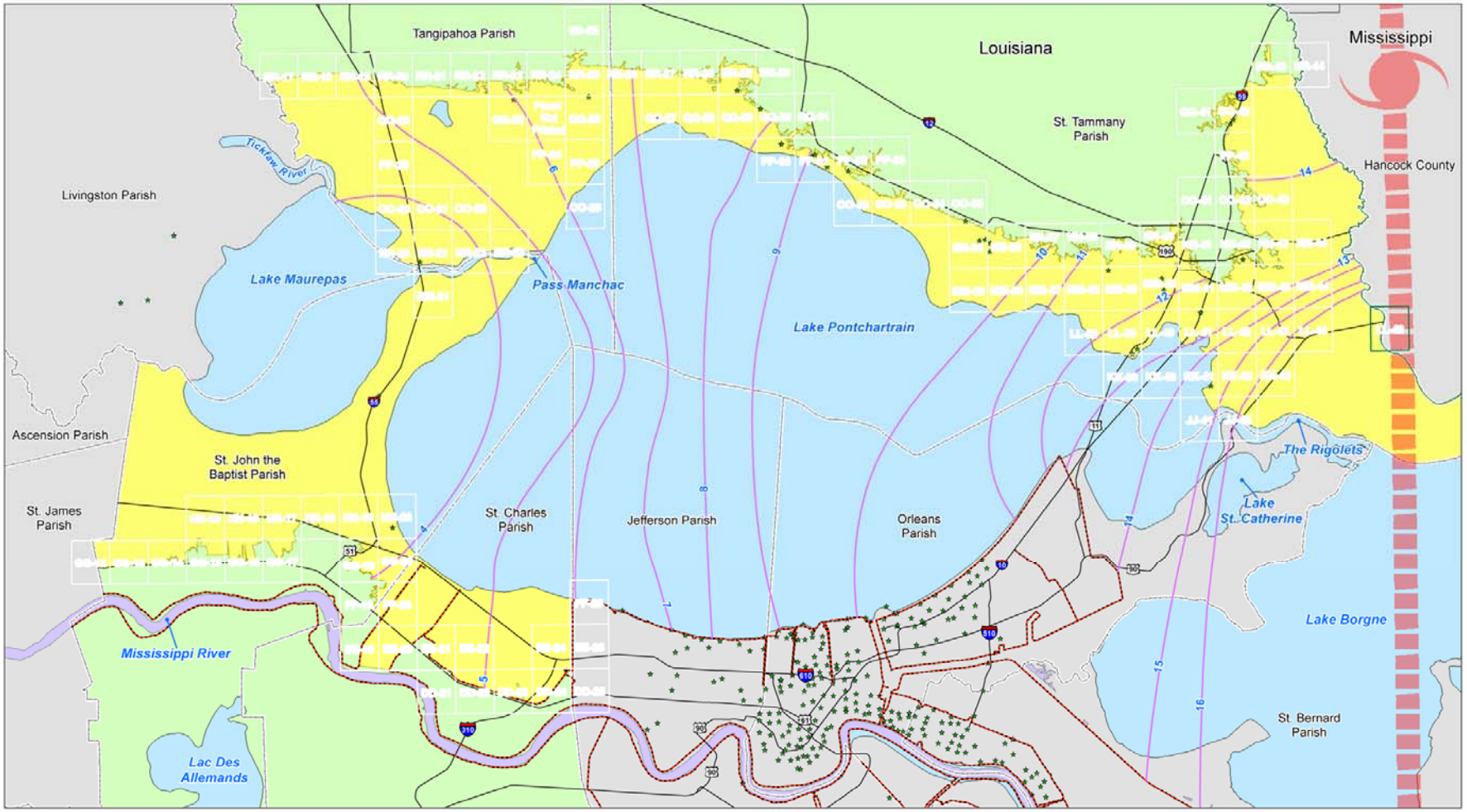
Legend

- State Boundary
- County Boundary
- Highway
- Water Feature
- Path of Hurricane Katrina
- Inundation Map Panel Grid
- Limit of Surge Inundation
- Preliminary High Water Marks
- Preliminary Surge Elevations
- ABFE Open Coast/BackBay Boundary

N

0 5 10 15 20

Miles



Louisiana Hurricane Katrina Surge Inundation and Advisory Base Flood Elevation Map Panel Overview
North Area

Date of Event: August 29, 2005; Date of Map: January 2006

FEMA

Legend

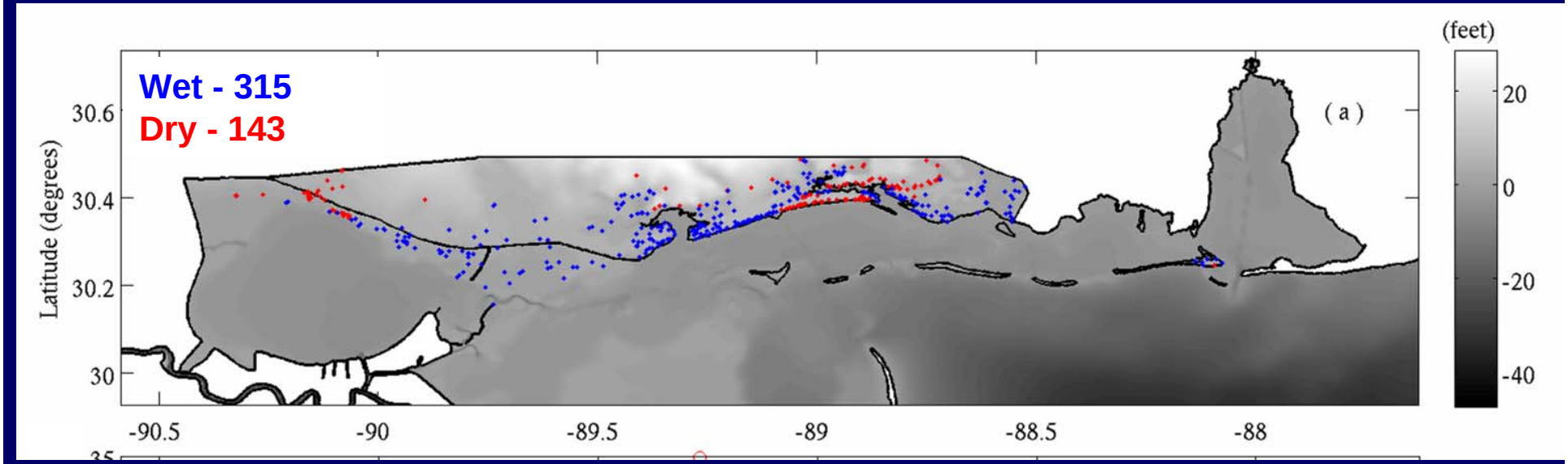
- State Boundary
- Parish Boundary
- Highway
- Levees
- Inundation Map Panel Grid
- Limit of Surge Inundation
- Preliminary High Water Marks
- Preliminary Surge Elevations
- Path of Hurricane Katrina

N

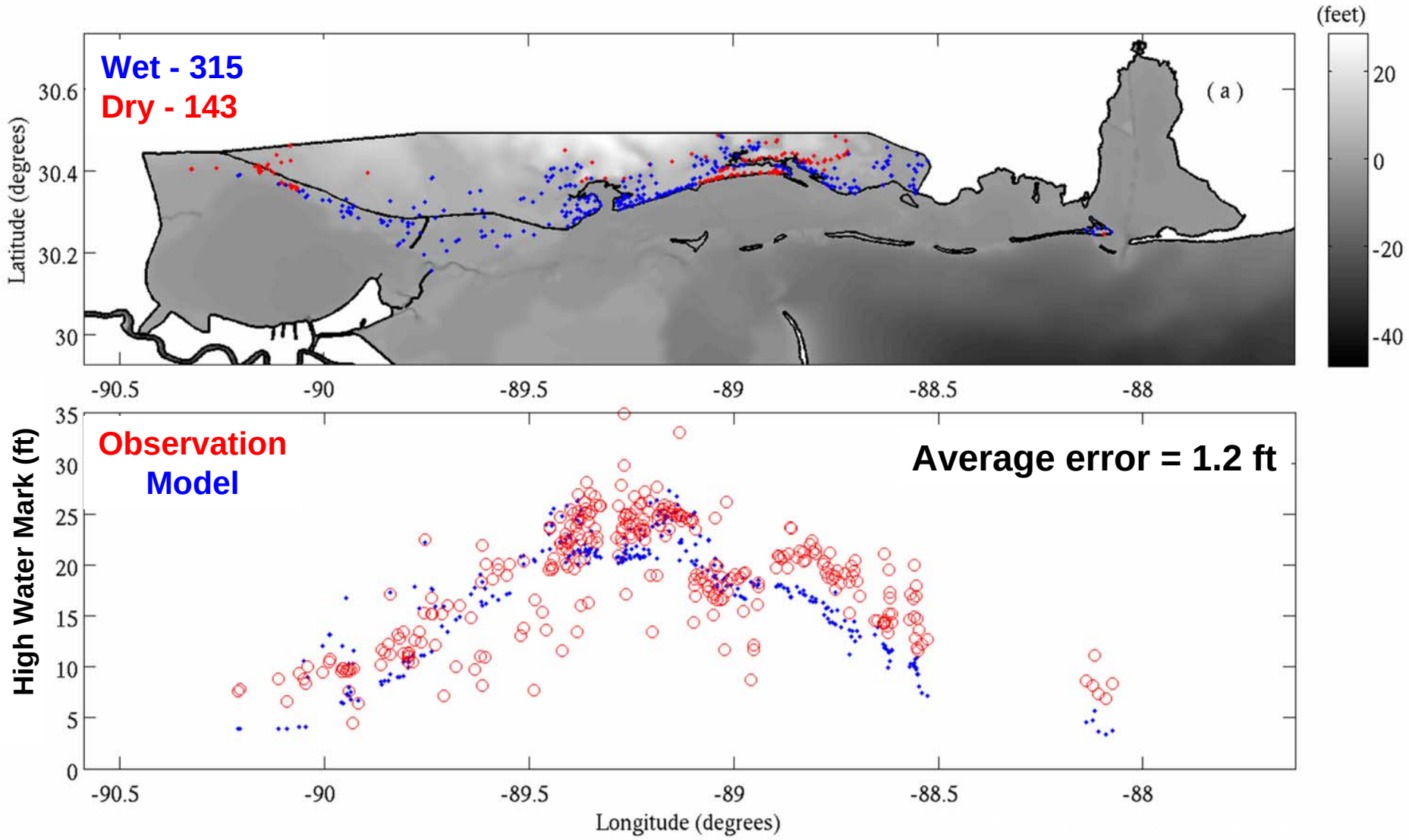
0 5 10 15 20

Miles

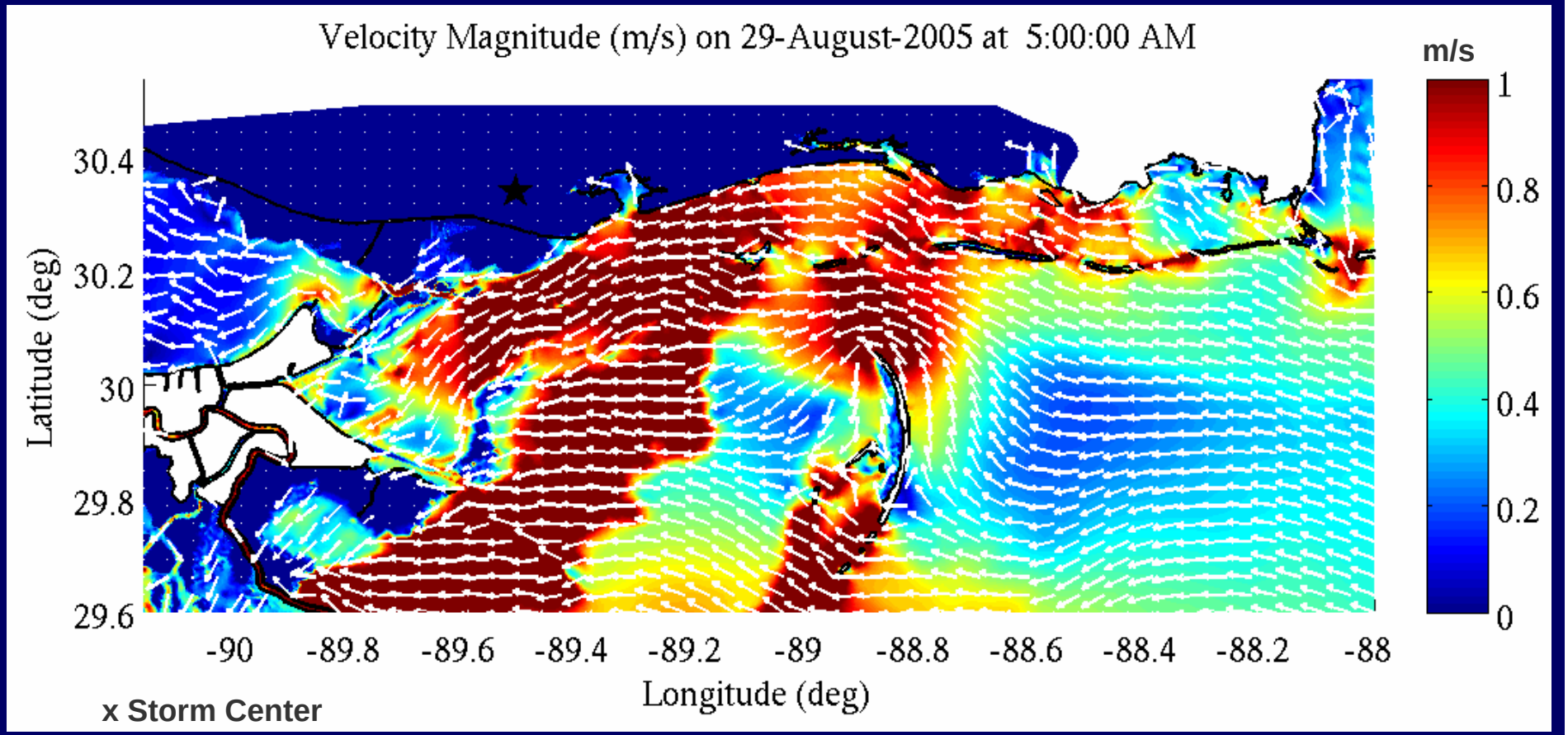
Comparison to USGS High Water Marks



Comparison to USGS High Water Marks



ADCIRC Computed Currents



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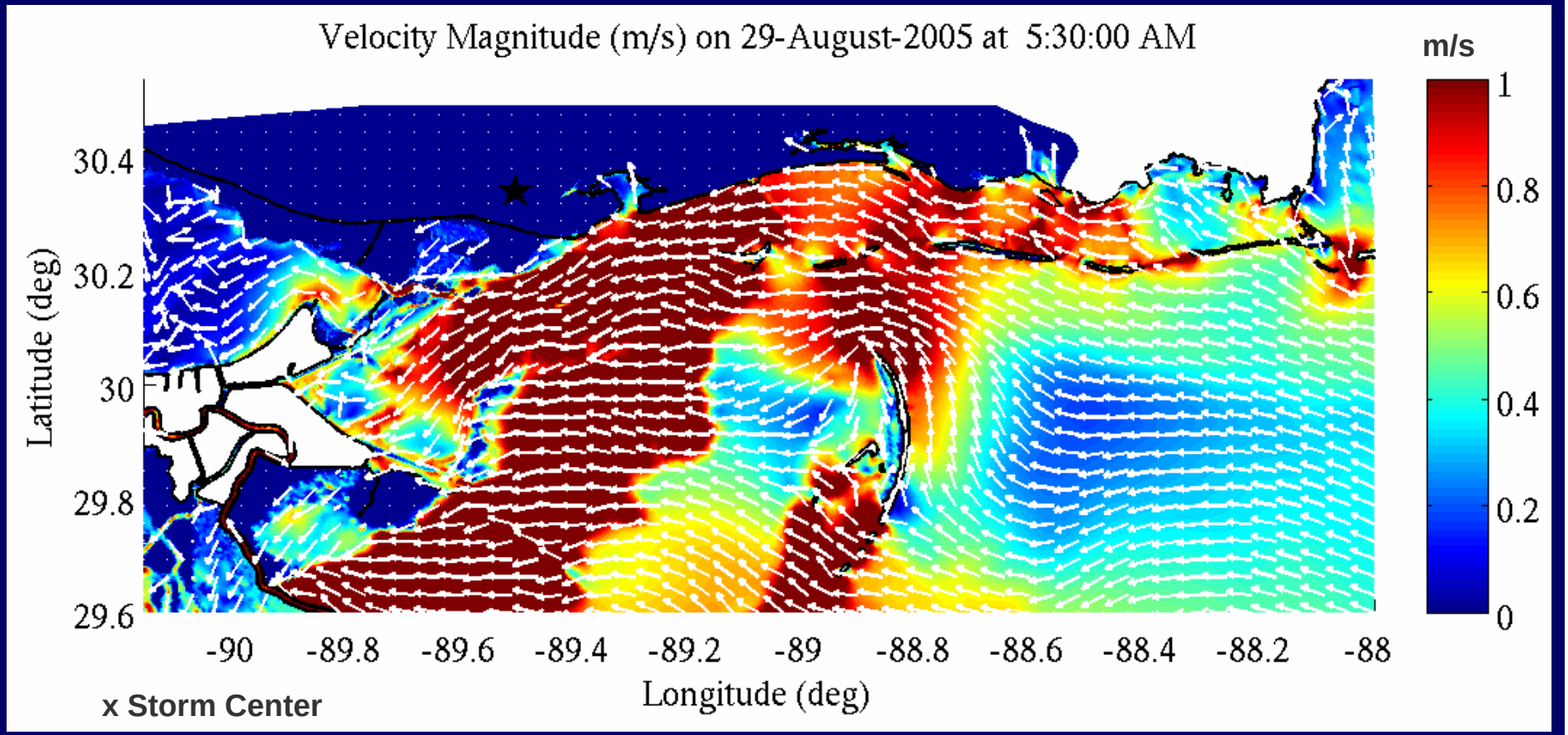

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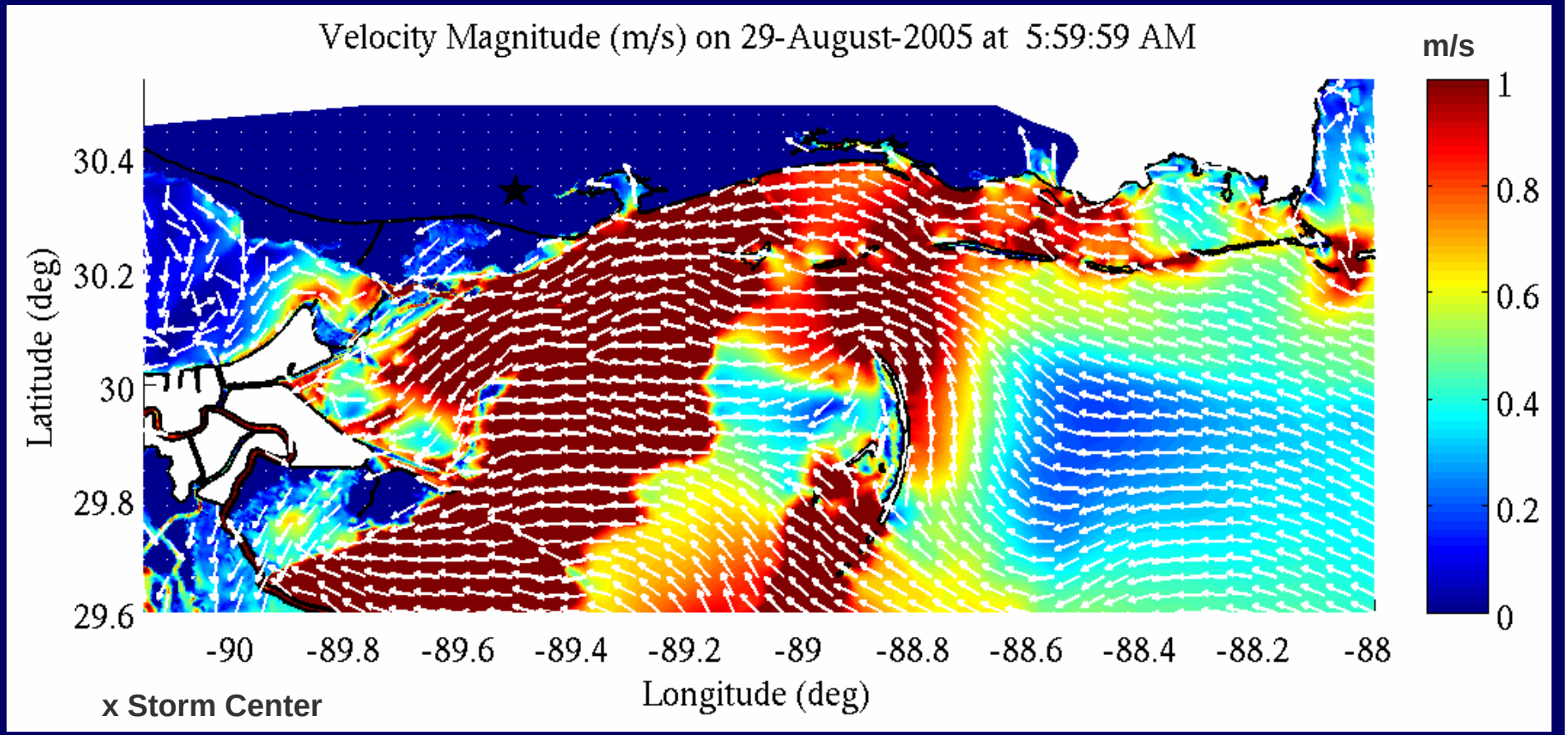

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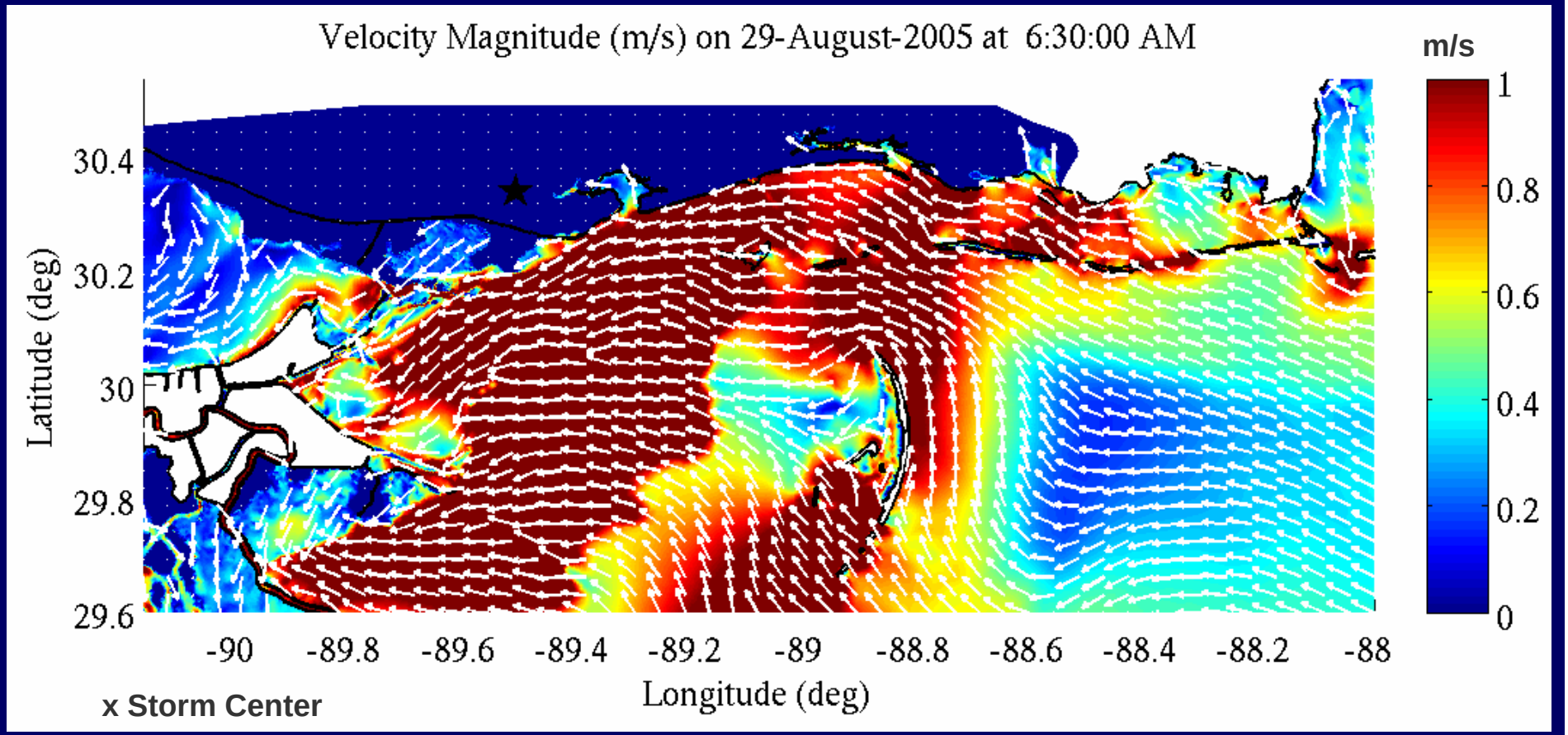

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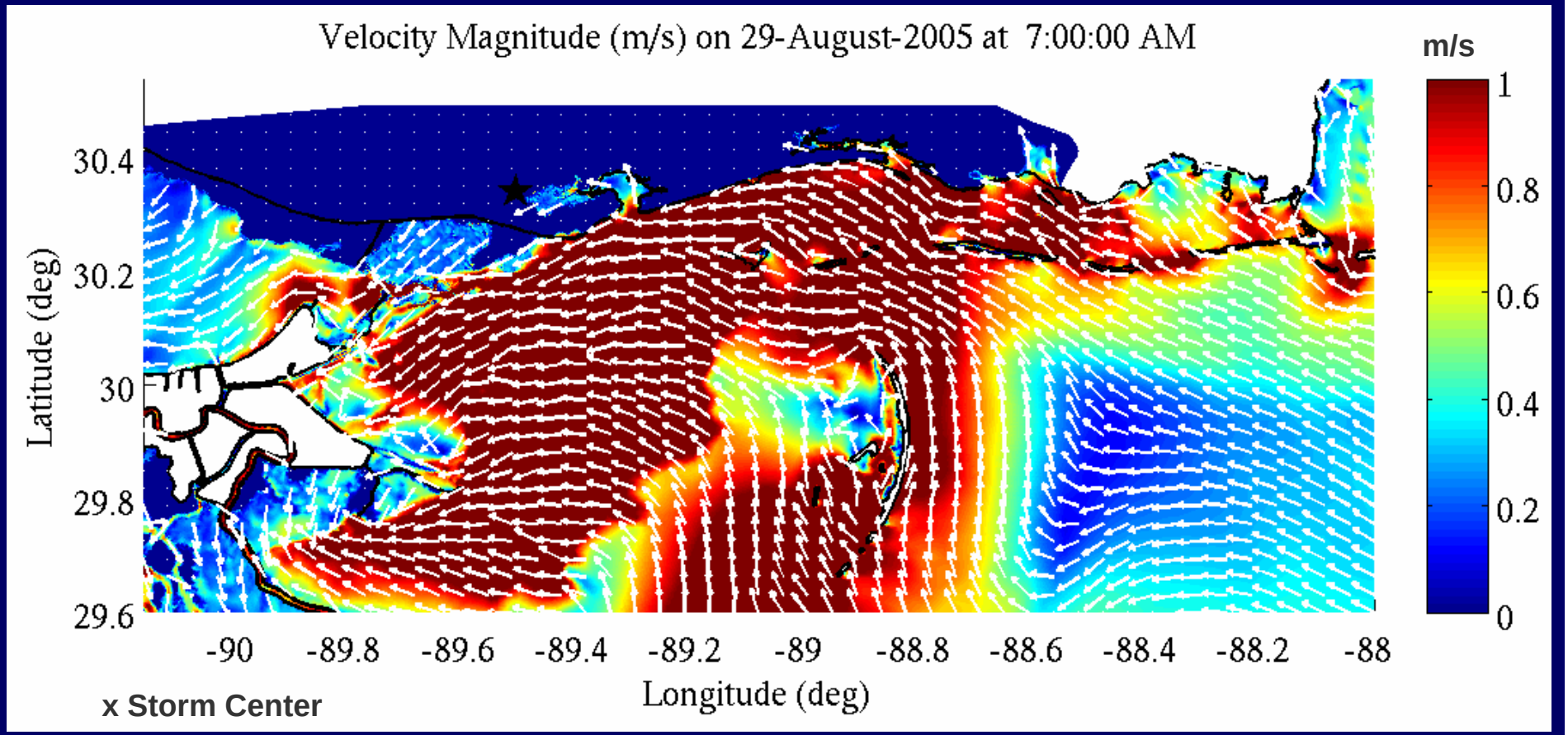

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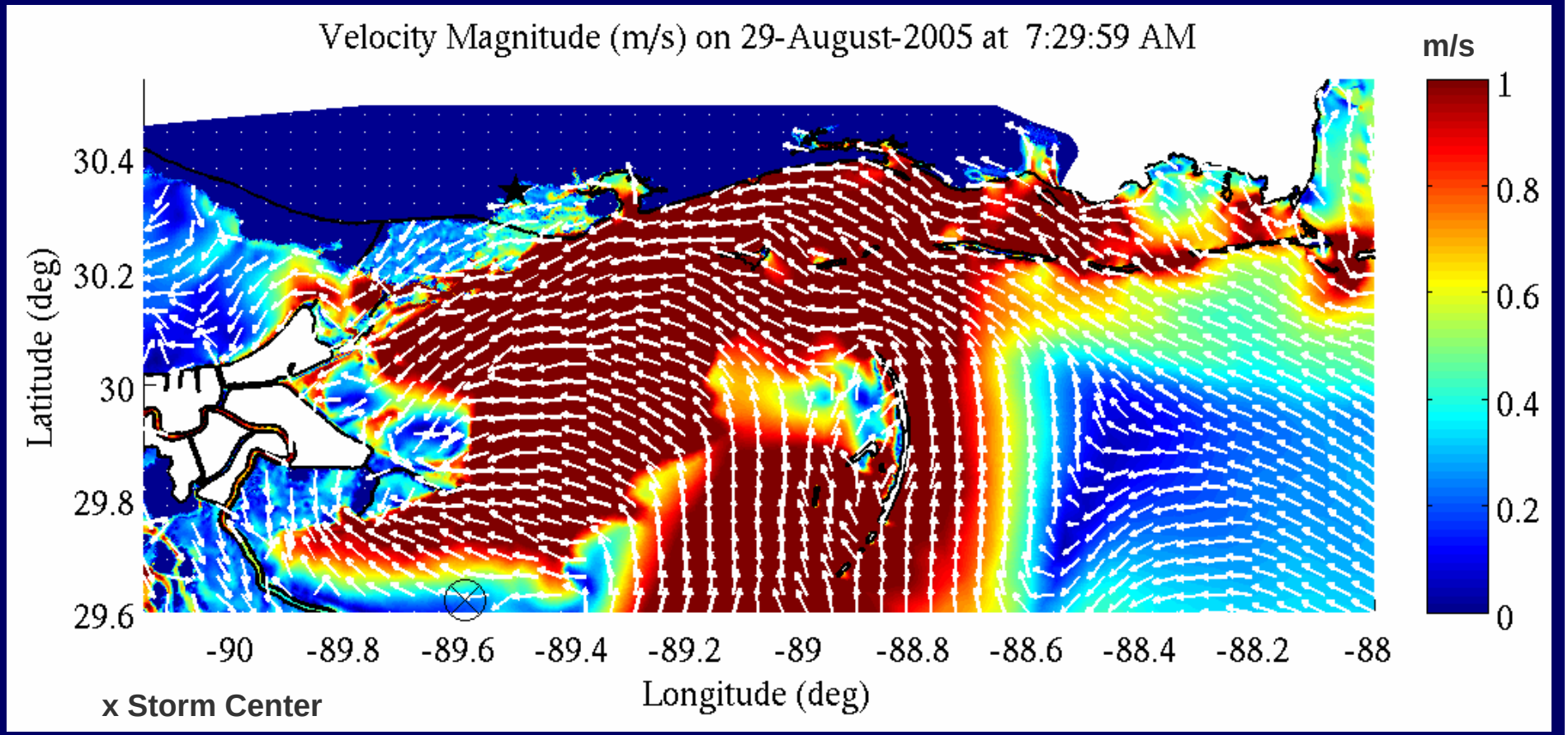

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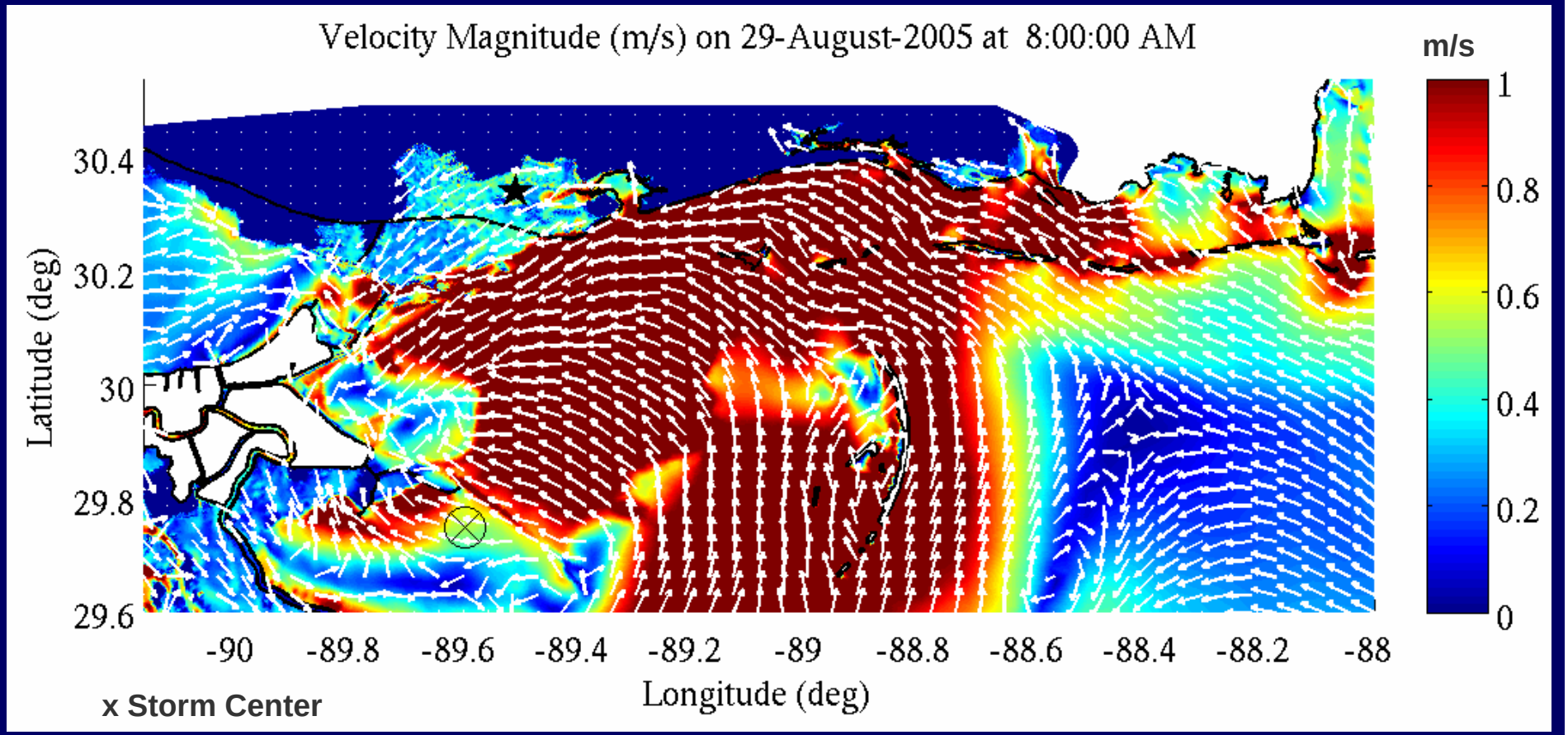

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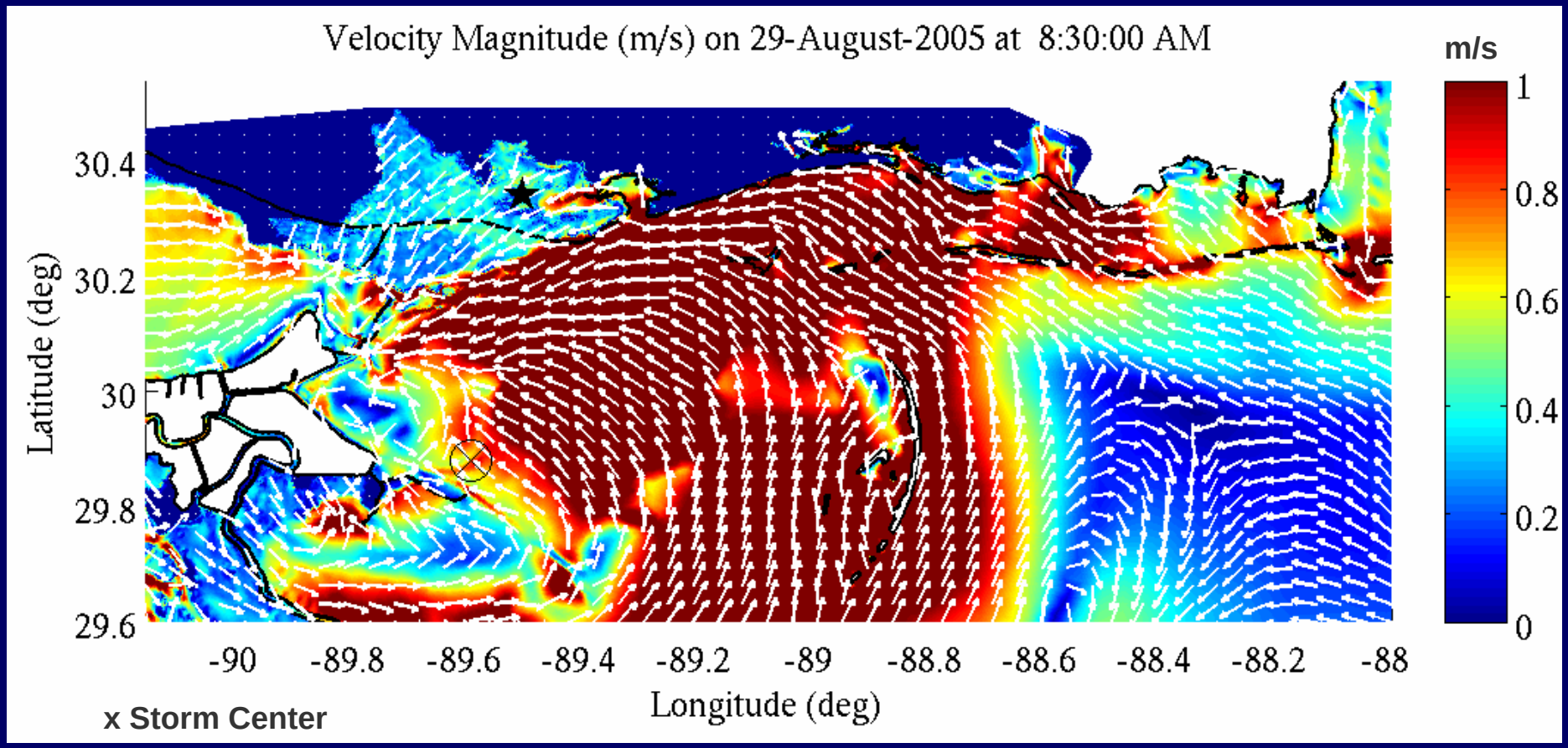

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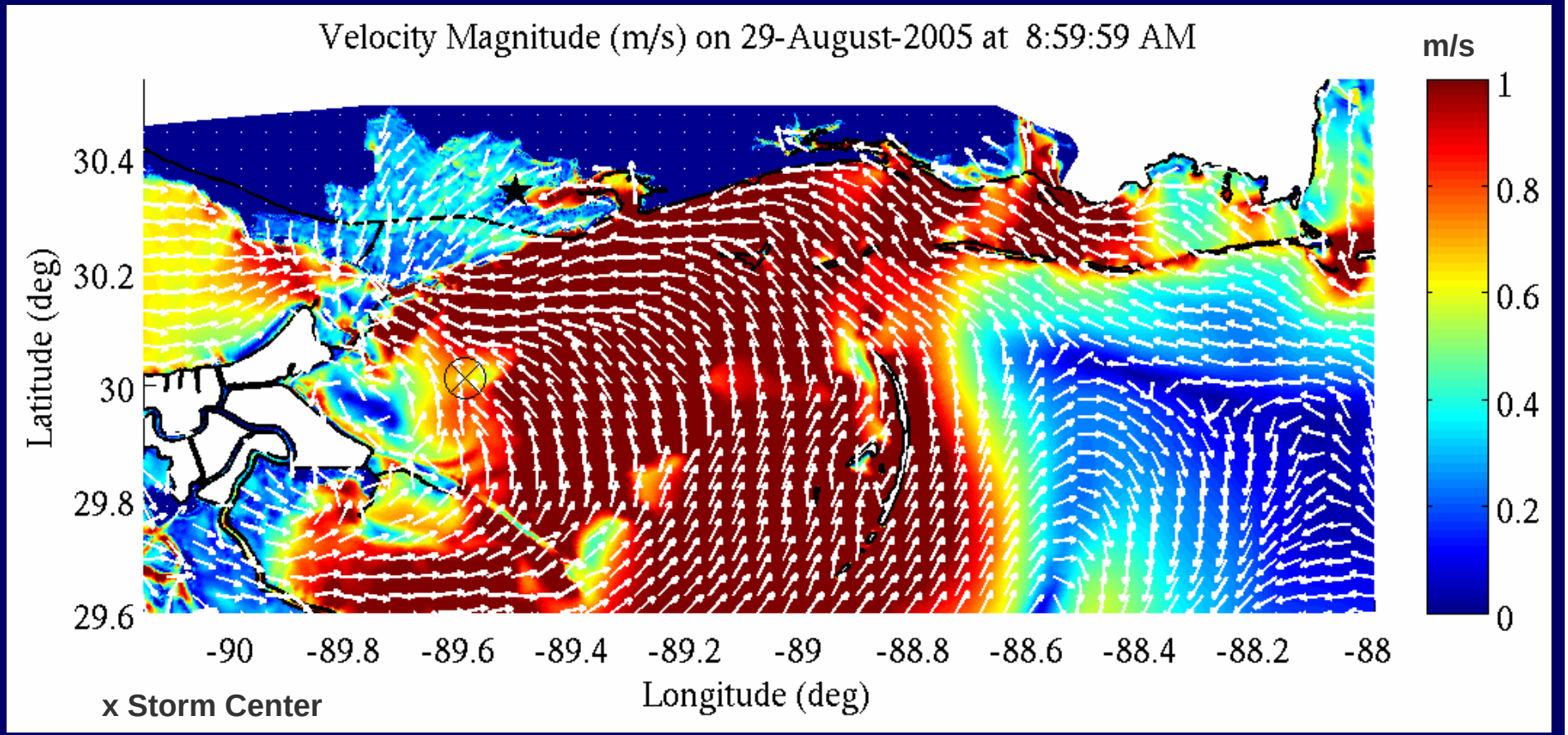

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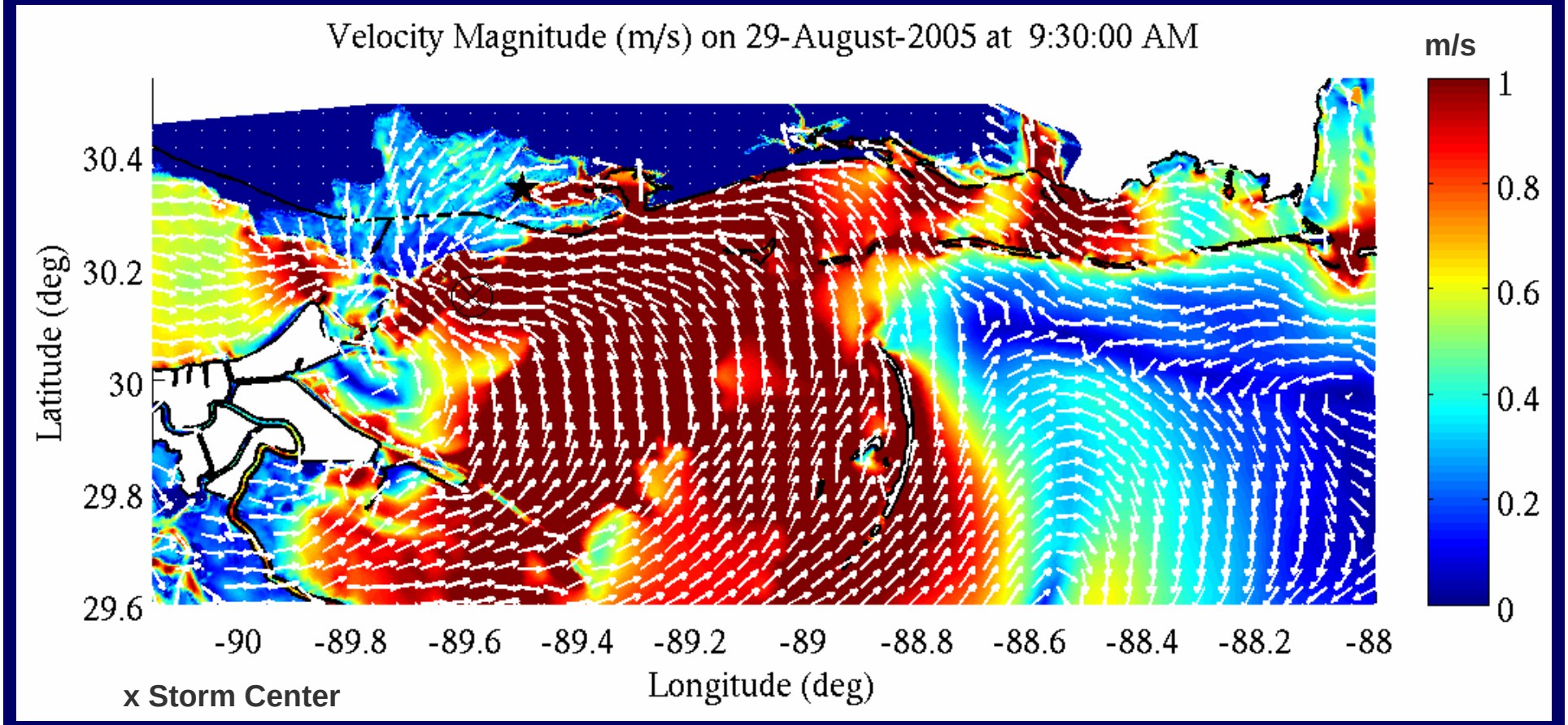

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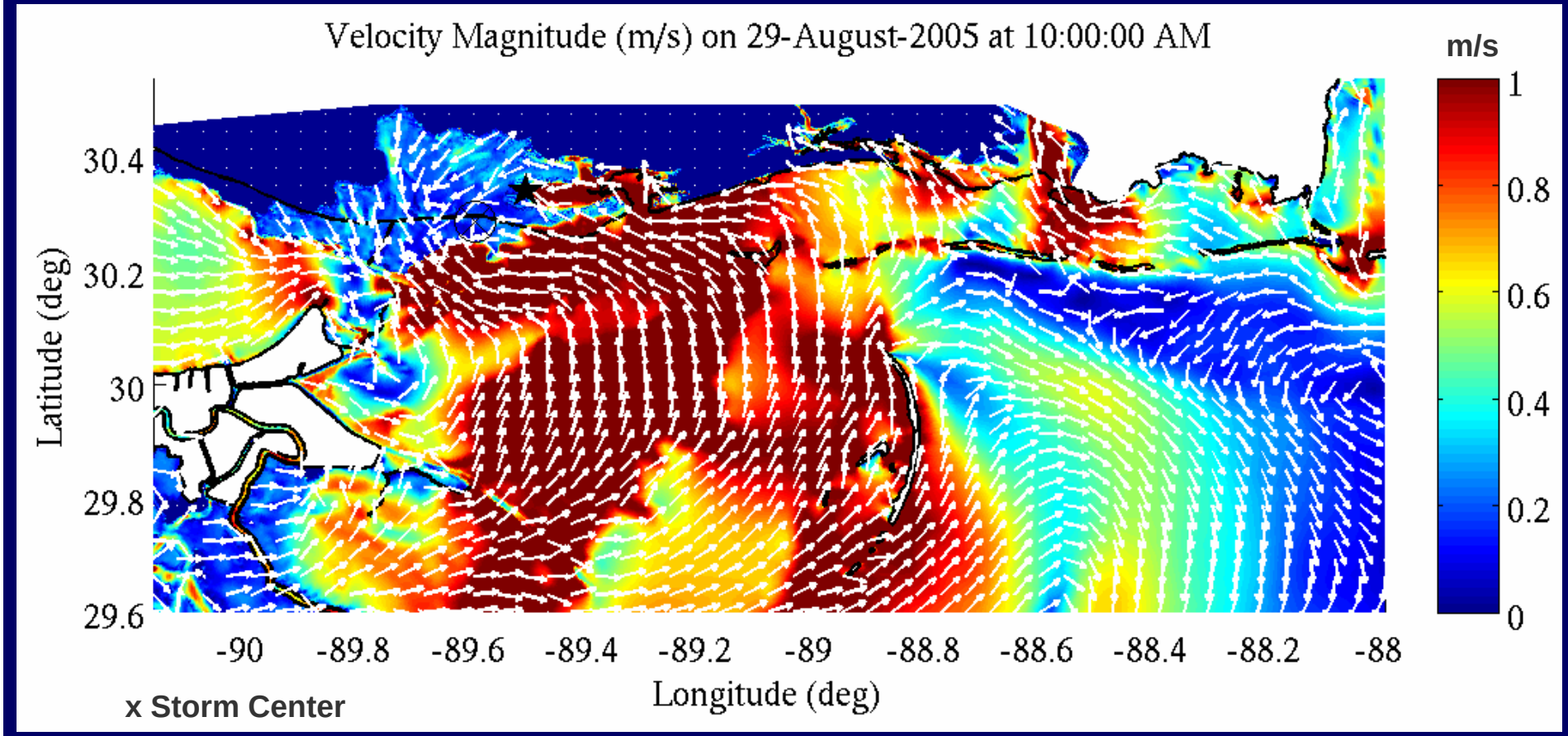

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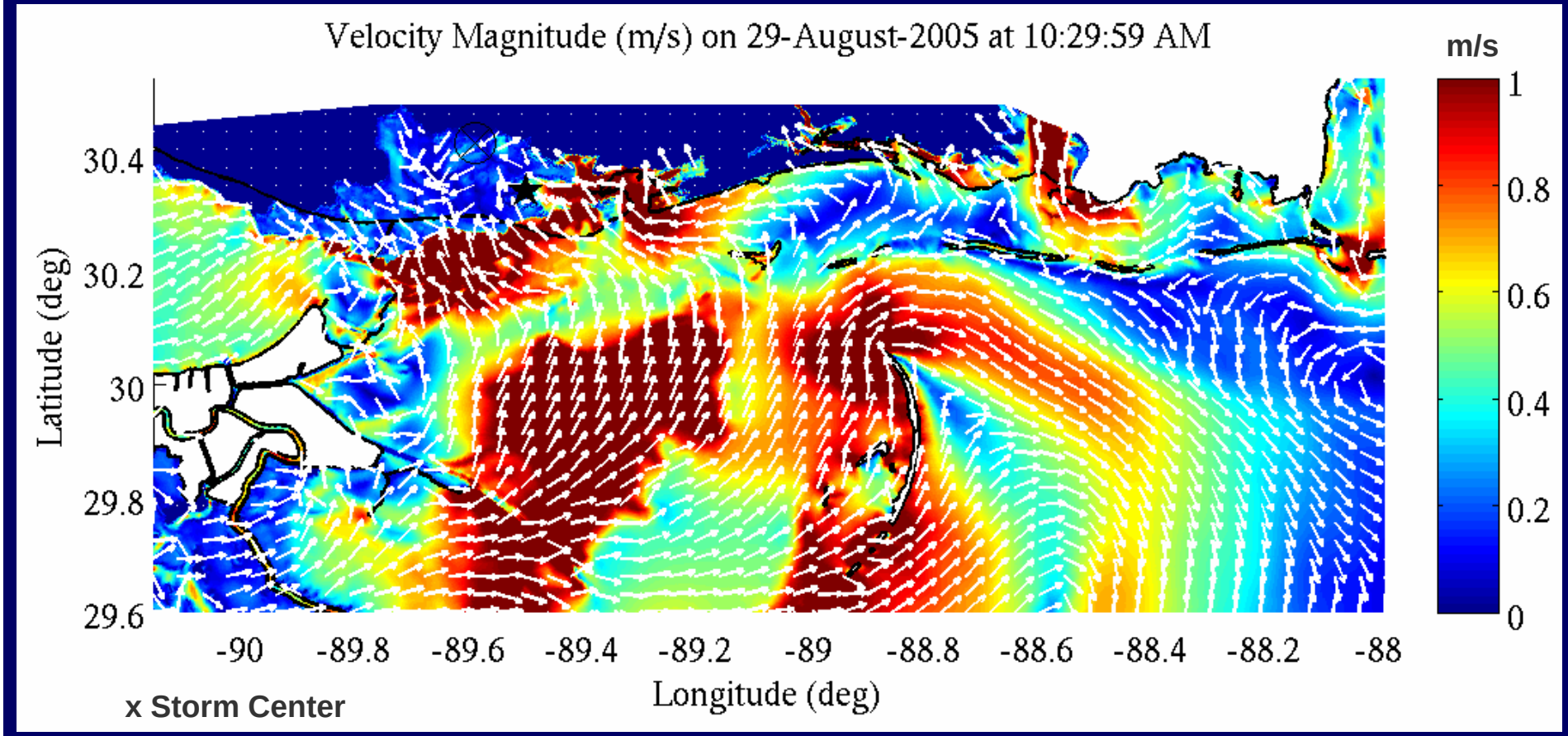

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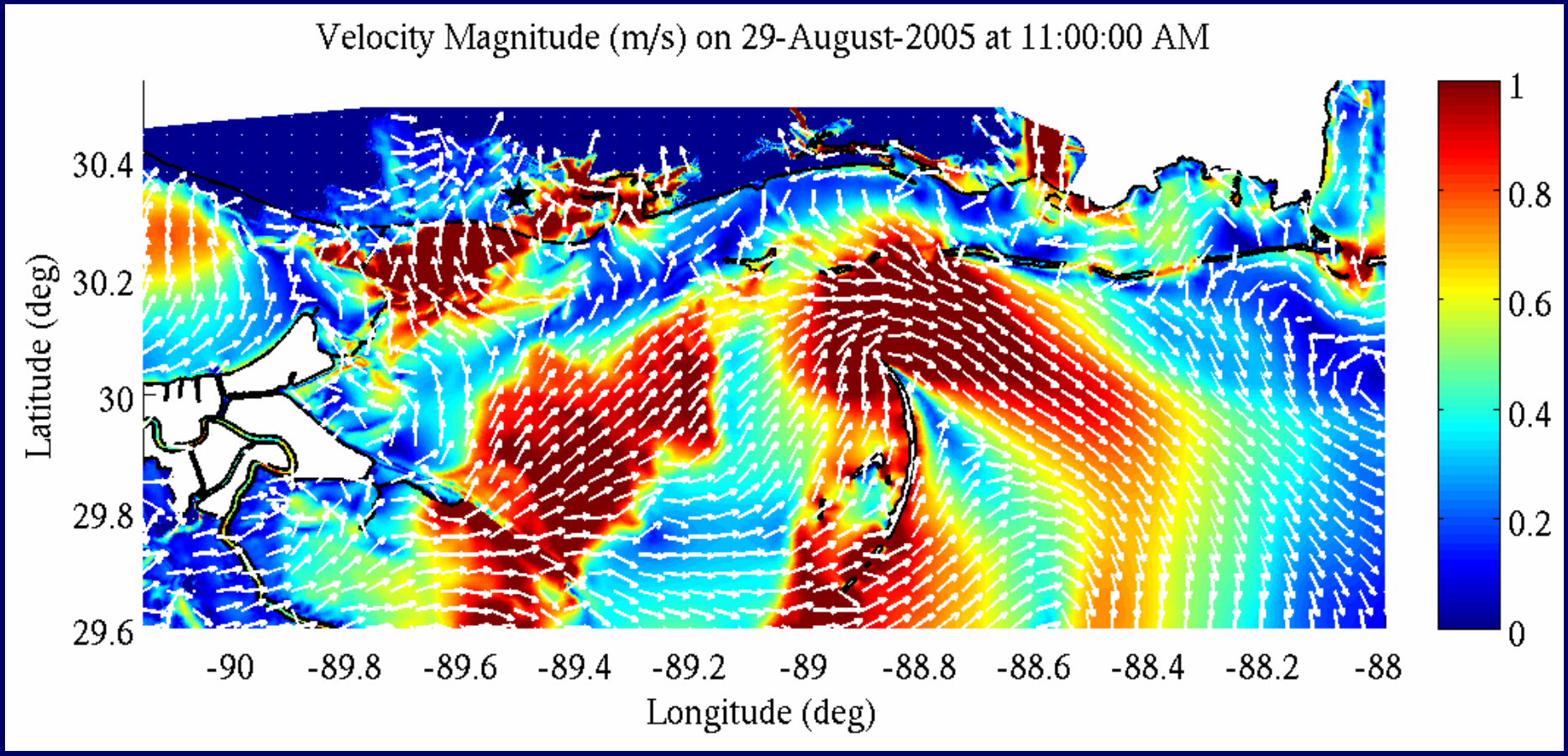

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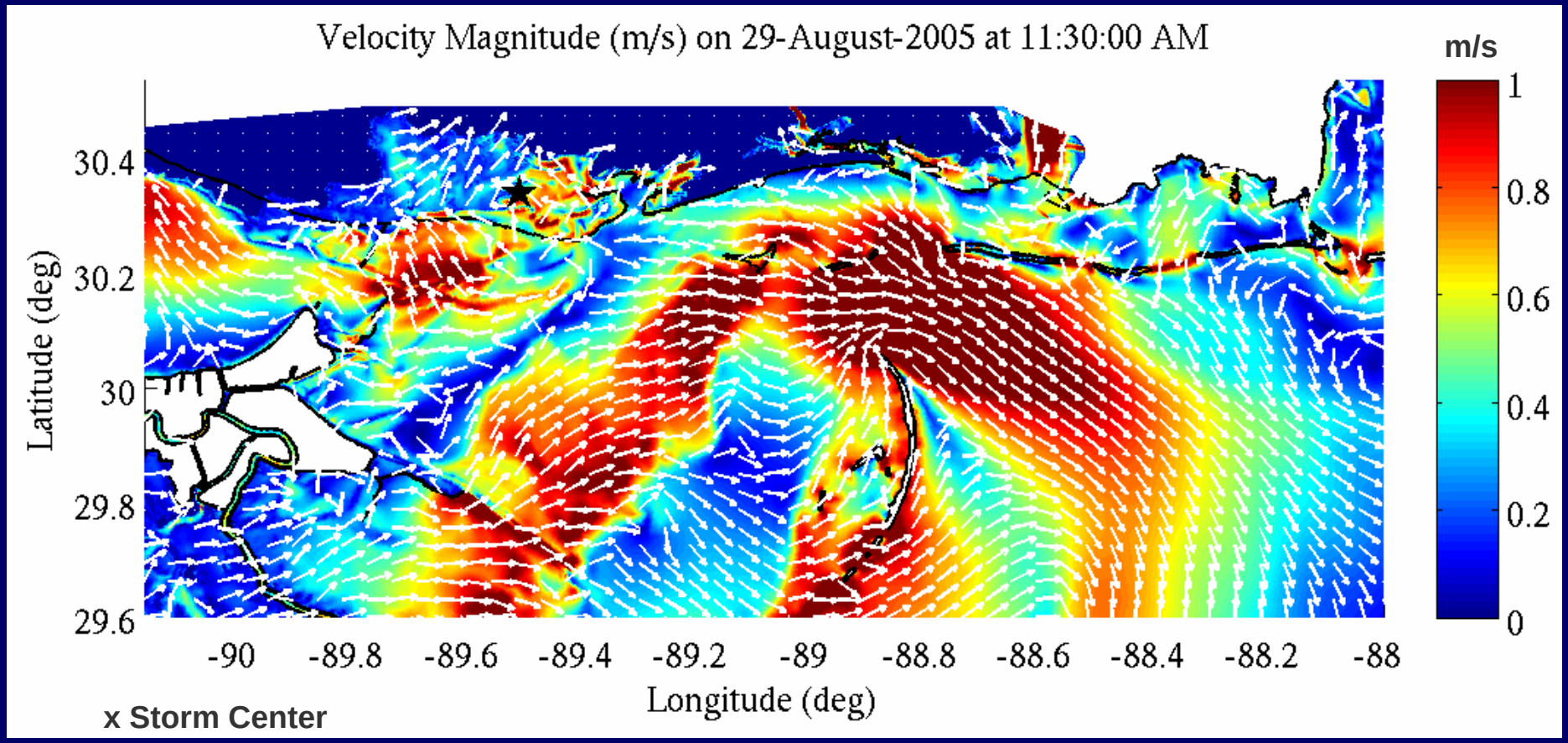

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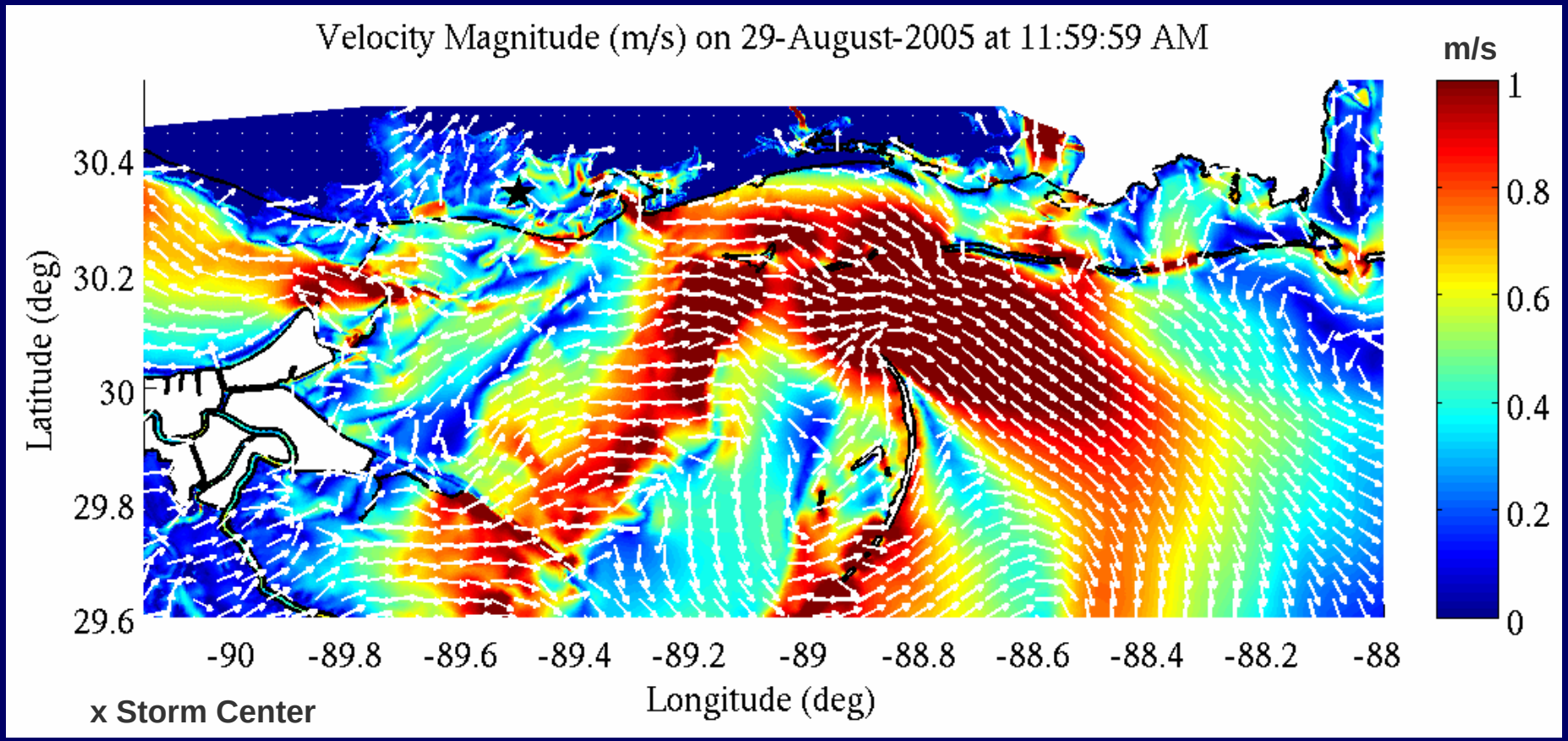

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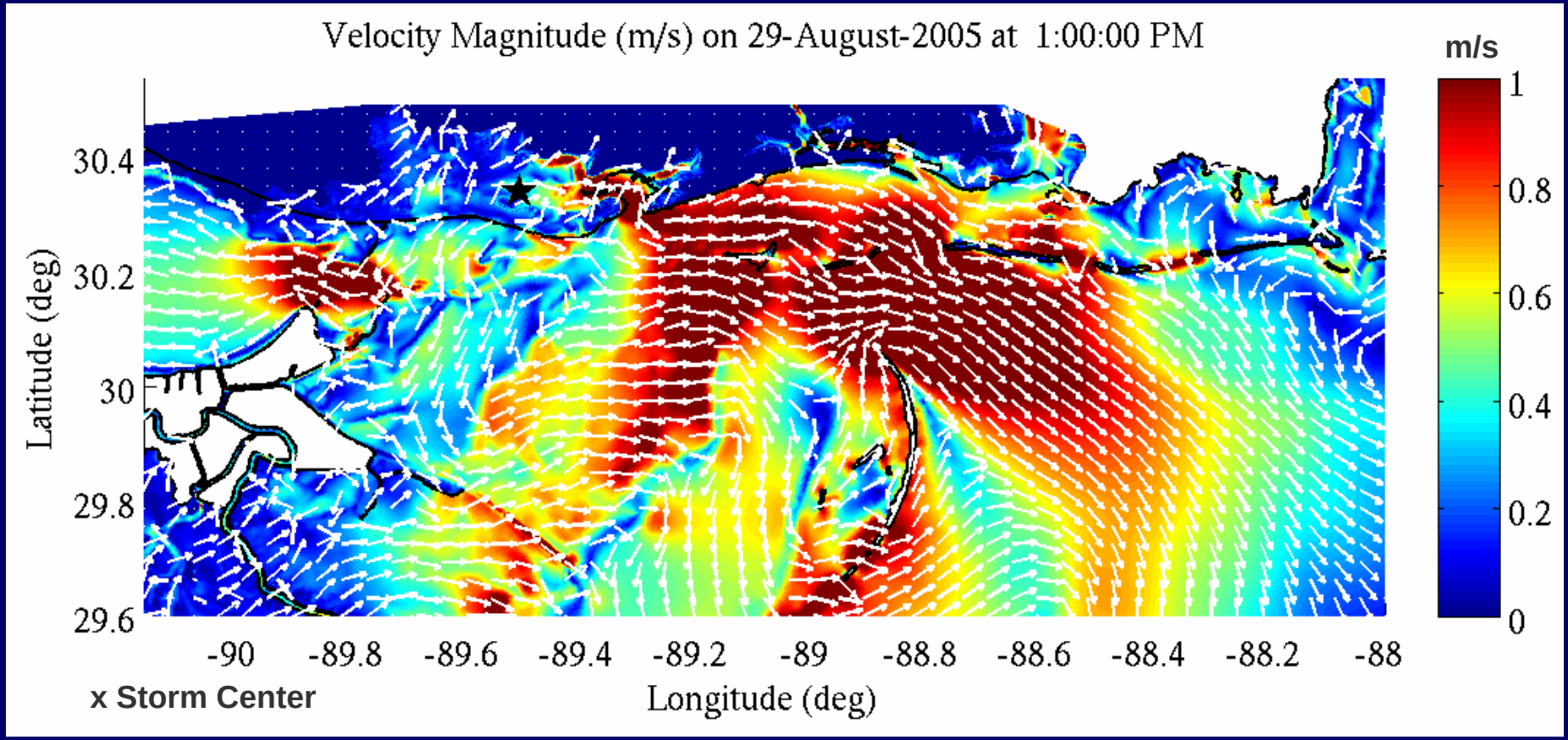

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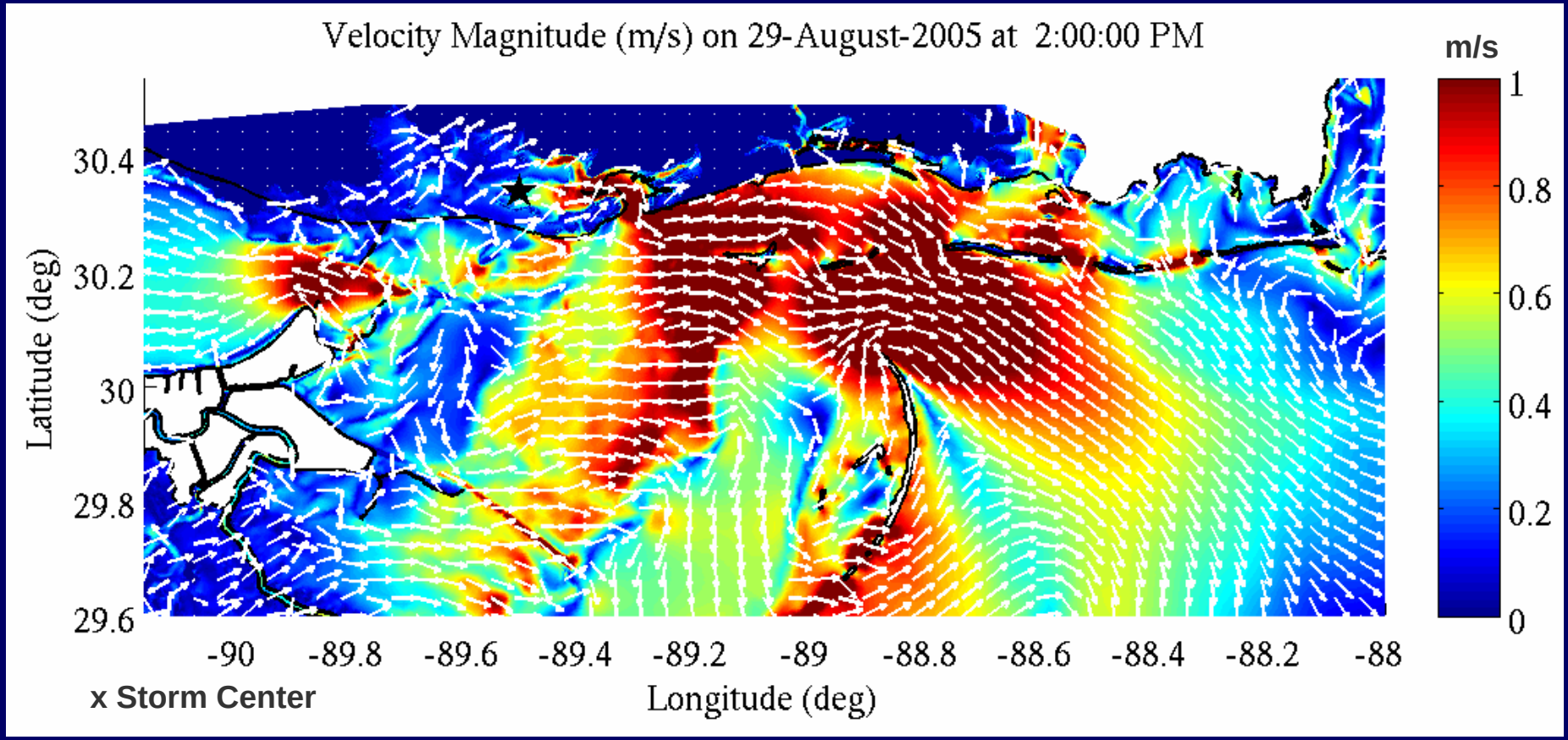

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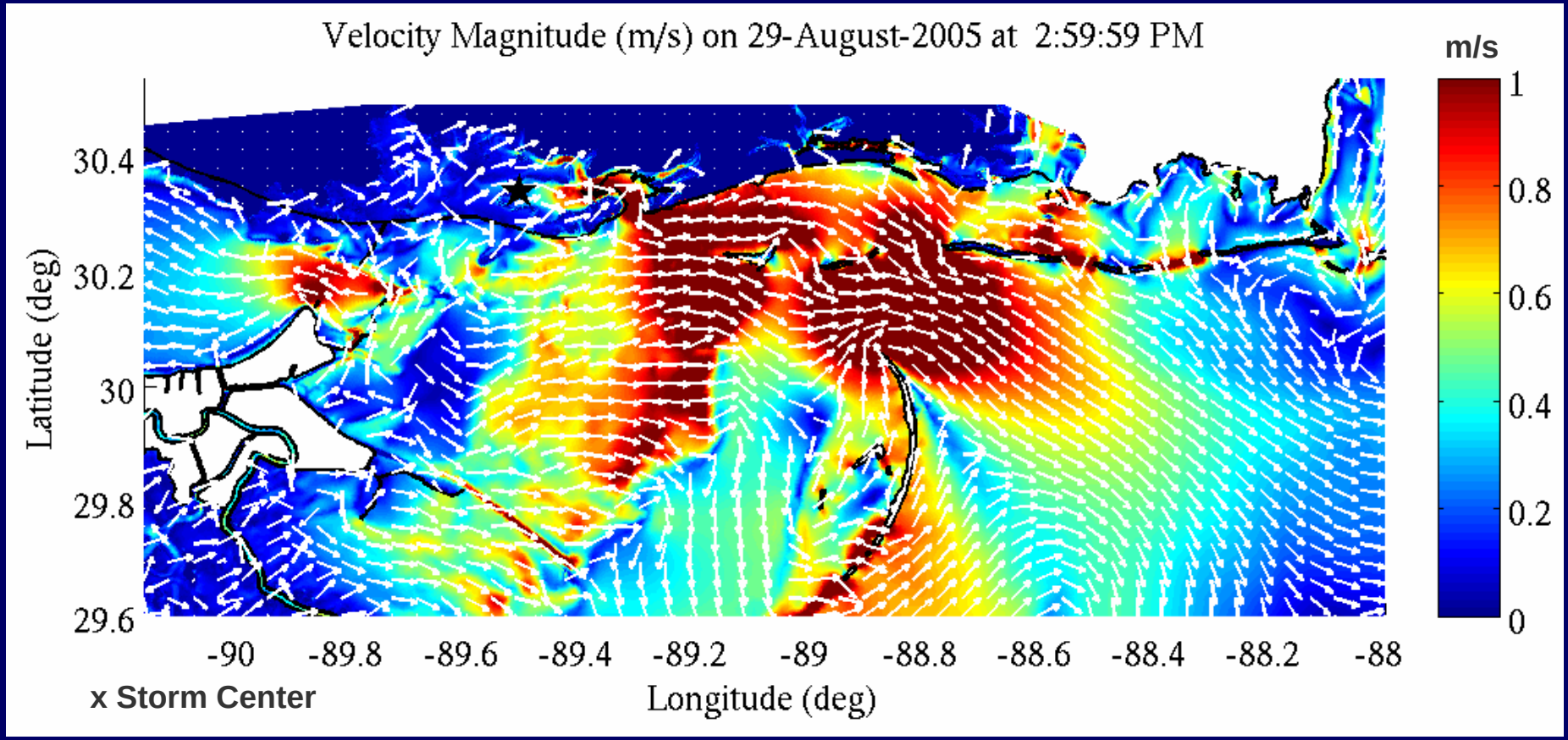

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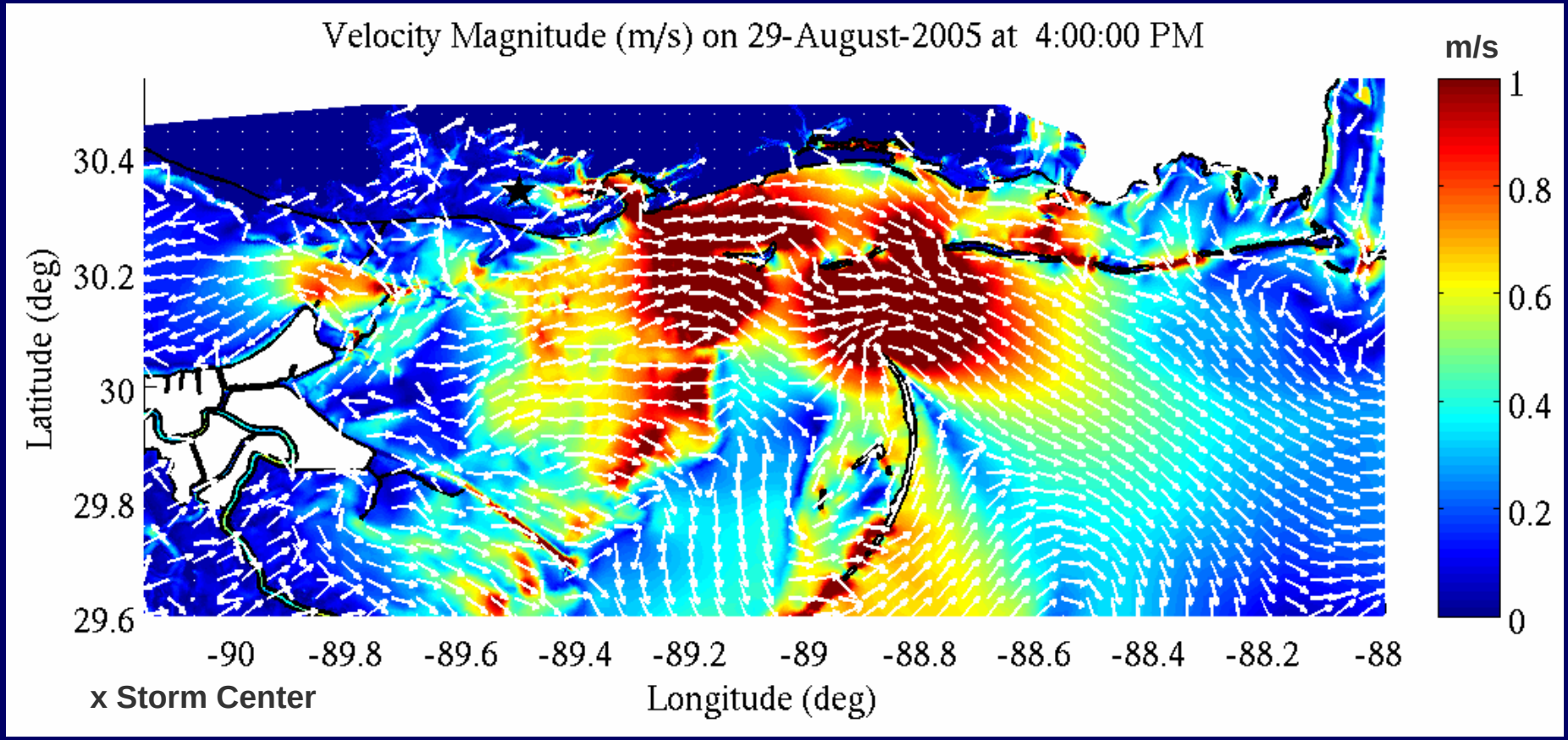

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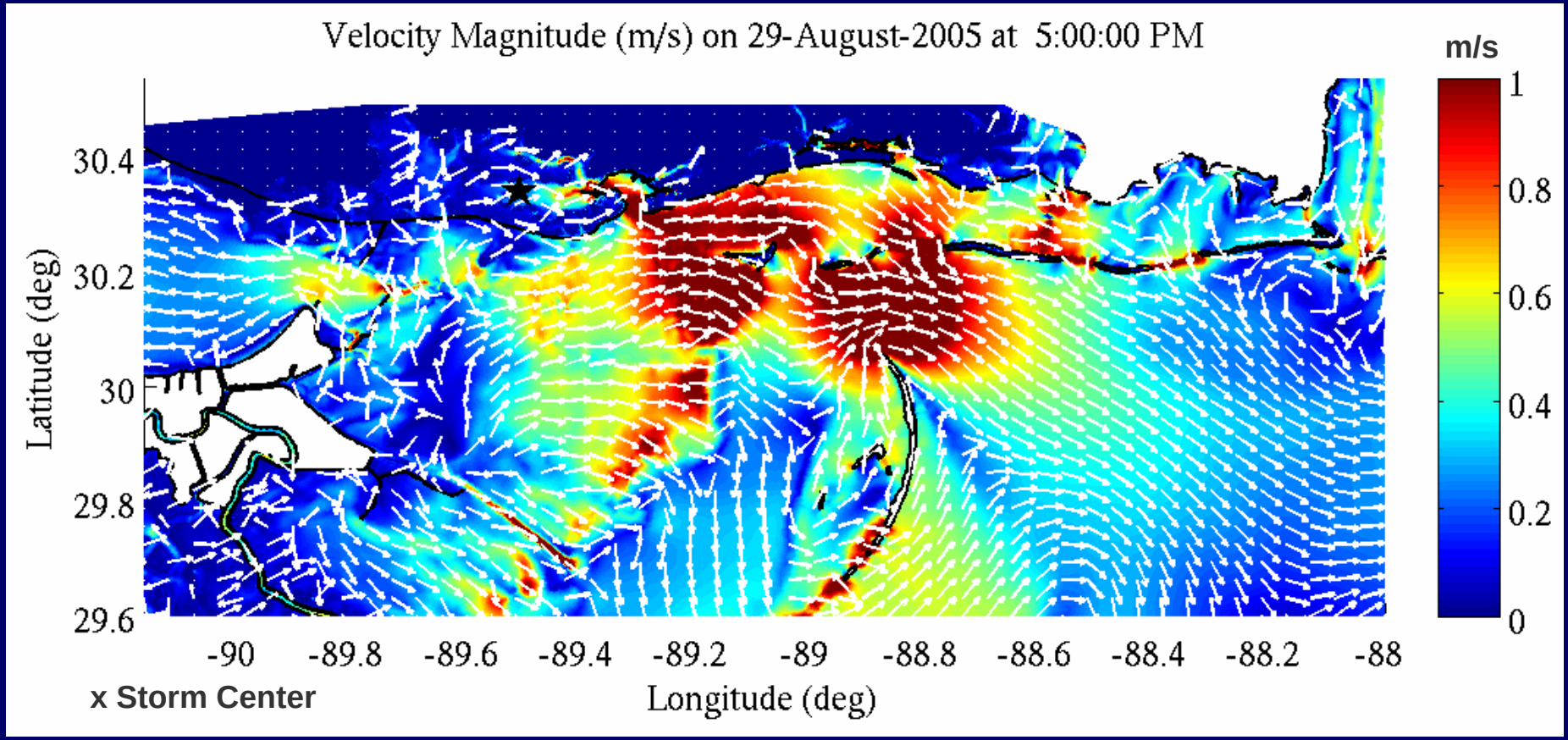
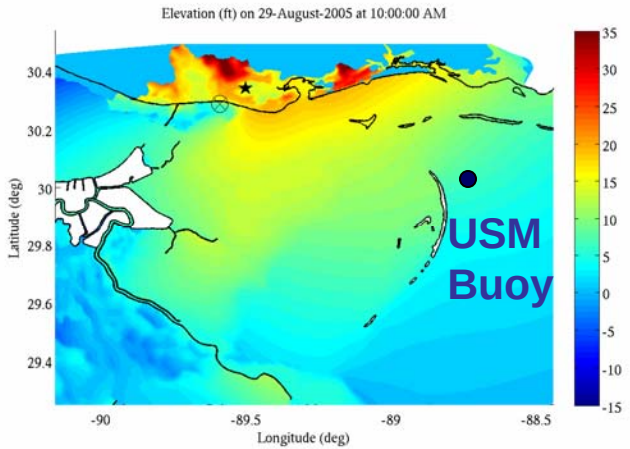
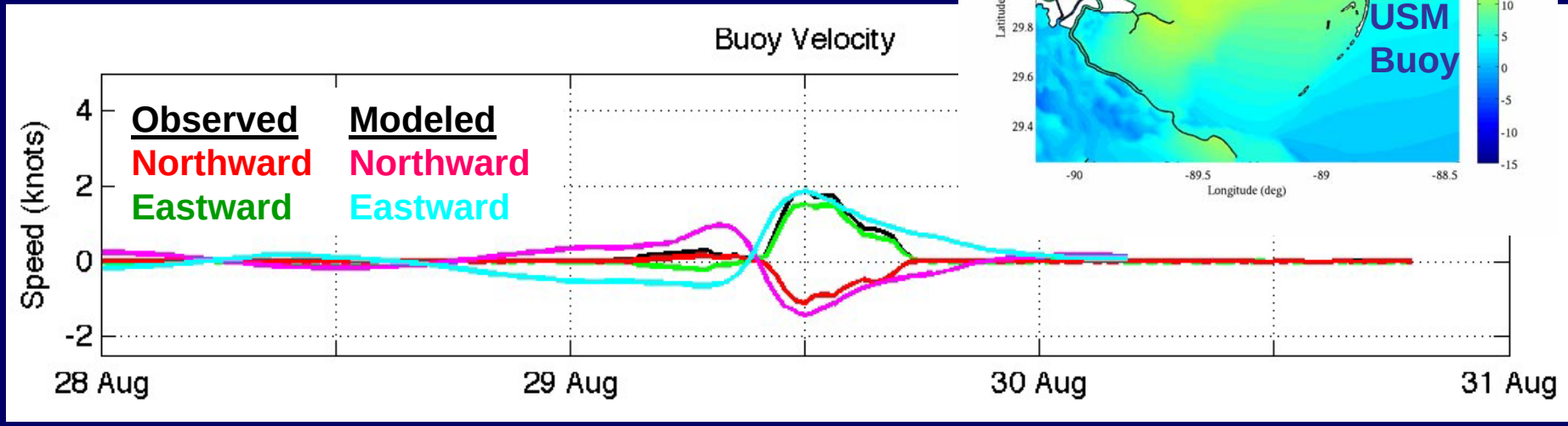
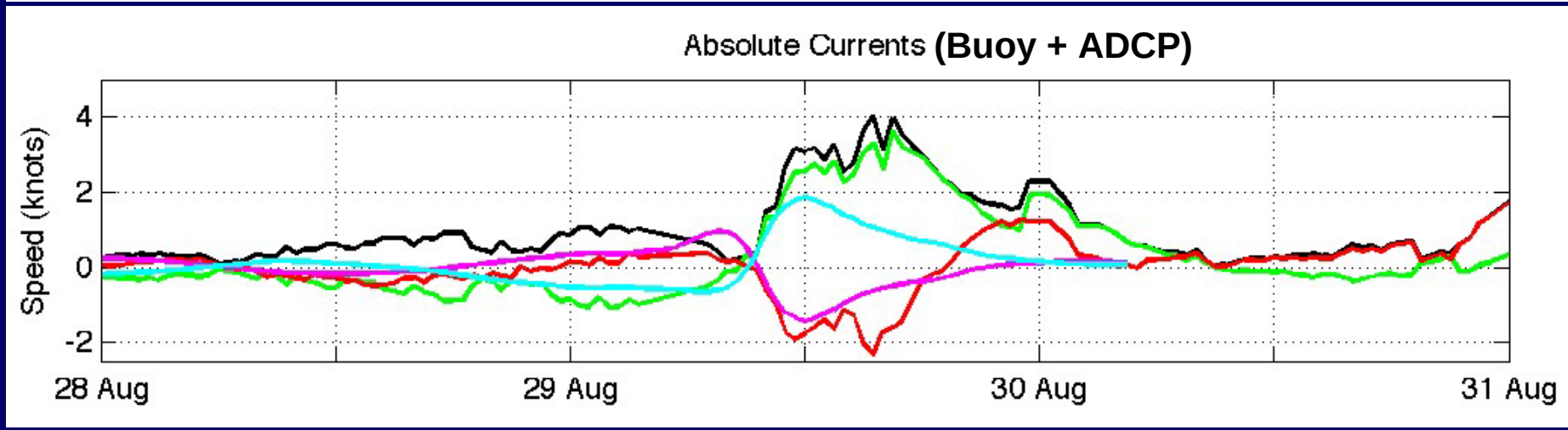


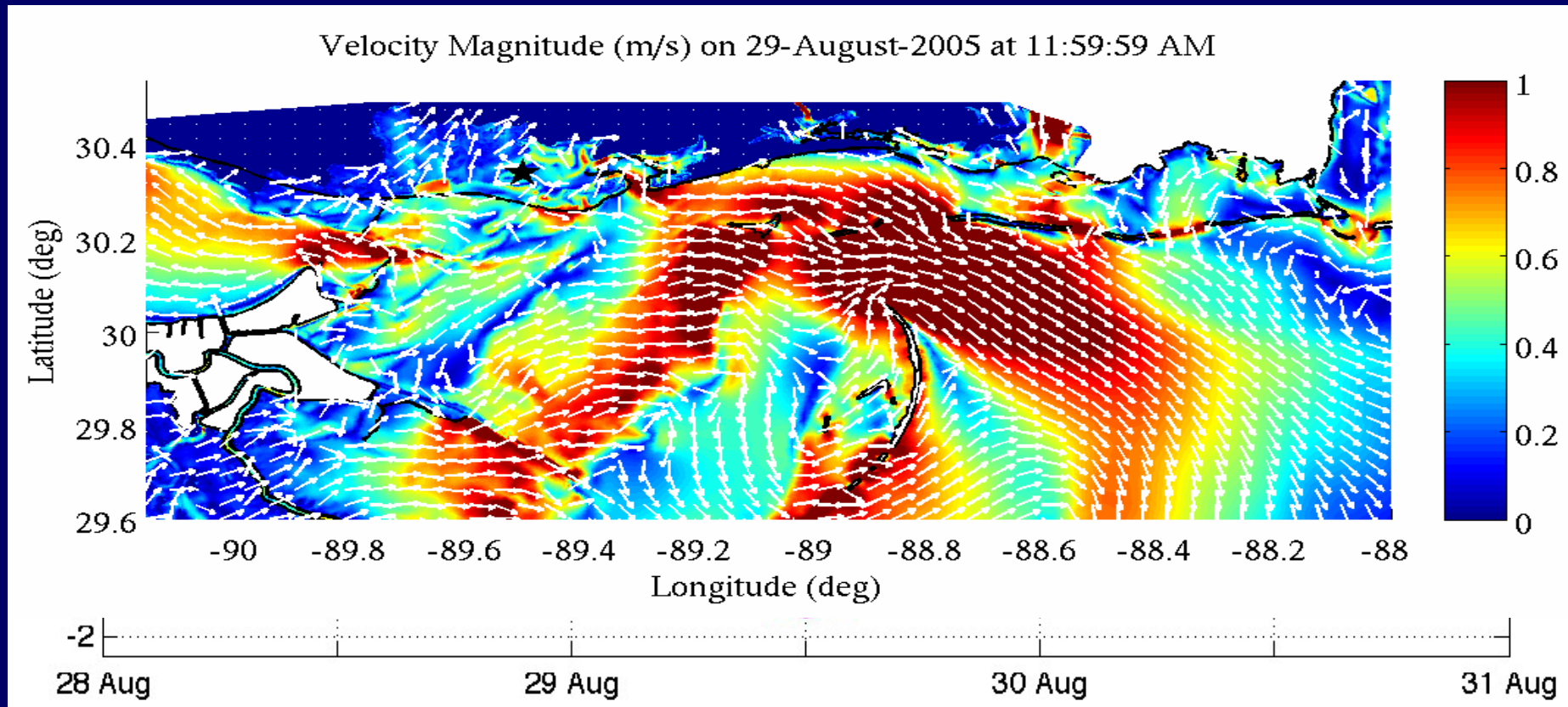
Current Comparisons

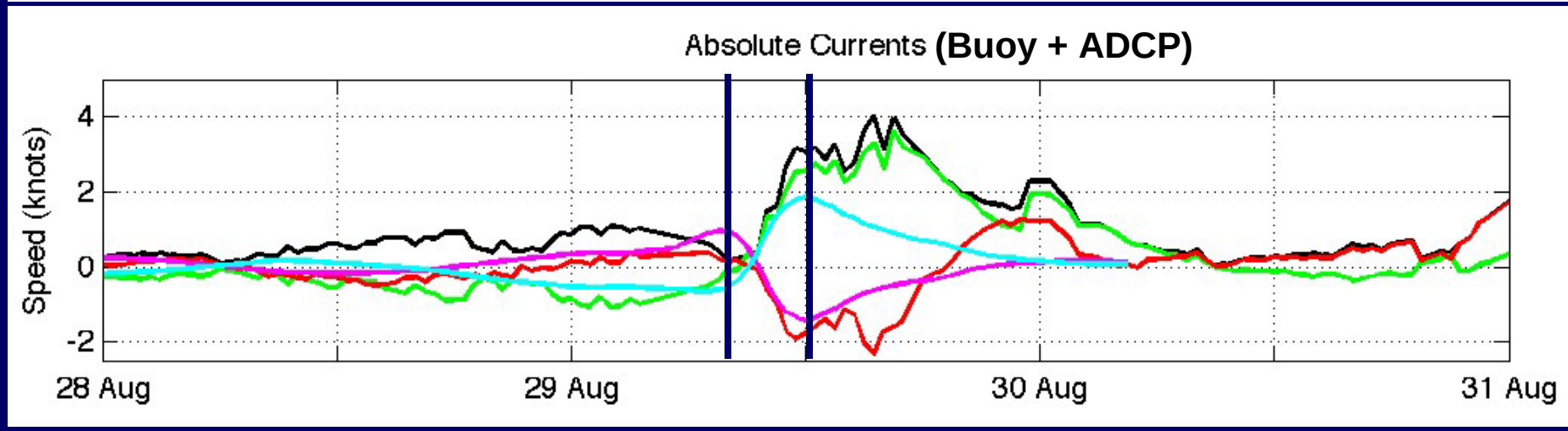
USM Buoy (Courtesy: Dr. Stephan Howden)







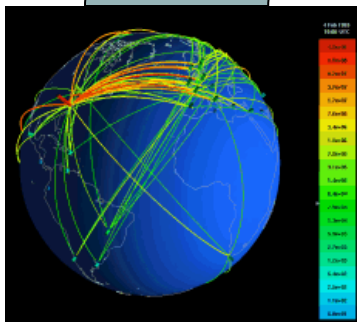

Velocity Magnitude (m/s) on 29-August-2005 at 11:59:59 AM
Latitude (deg)
30.4
30.2
30
29.8
29.6
-90
-89.8
-89.6
-89.4
-89.2
-89
-88.8
-88.6
-88.4
-88.2
-88
Longitude (deg)
1
0.8
0.6
0.4
0.2
0
-2
28 Aug
29 Aug
30 Aug
31 Aug


Absolute Currents (Buoy + ADCP)
Speed (knots)
4
2
0
-2
28 Aug
29 Aug
30 Aug
31 Aug

DEVELOPED STORM SURGE PREDICTION SYSTEM

1

WWW NHC Marine Advisory Data



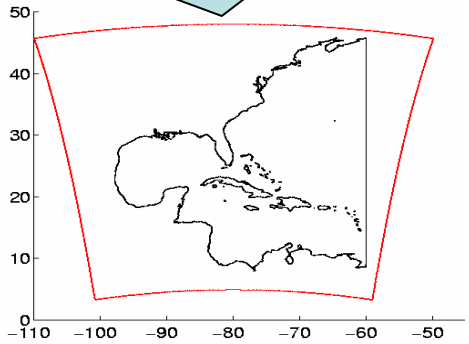
000 WTNT25 KNHC 062031 TCMAT5
TROPICAL DEPRESSION ZETA
FORECAST/ADVISORY NUMBER 30
NWS TPC/NATIONAL HU[illegible]
CENTER MIAMI

2100Z FRI JAN [illegible]

TROPICAL DEPRESSION

CENTER LOCATED NEAR 23.4N
50.3W ...

... FORECASTER STEWART $$



Interpolate W[illegible]

2

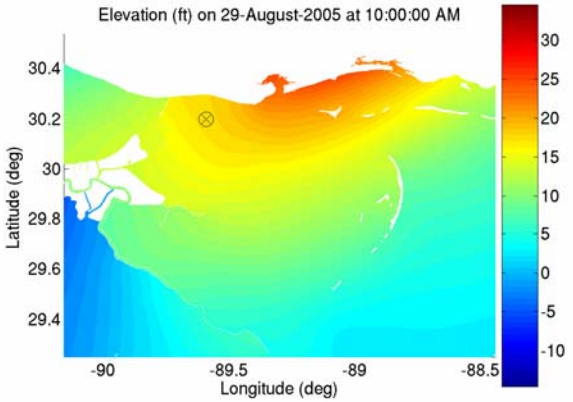
Run PC-Tides –

Obtain Holland Hurricane Model Winds

DELIVERED TO NAVOCEANO, May 2006

4

Run ADCIRC



The Model as a Planning Tool

Modularity of the model permits experimentation:

- isolate of physical processes
- determine role of geometric constraints
- examine sensitivity of forcing scenario
- begin to assign uncertainty to predictions

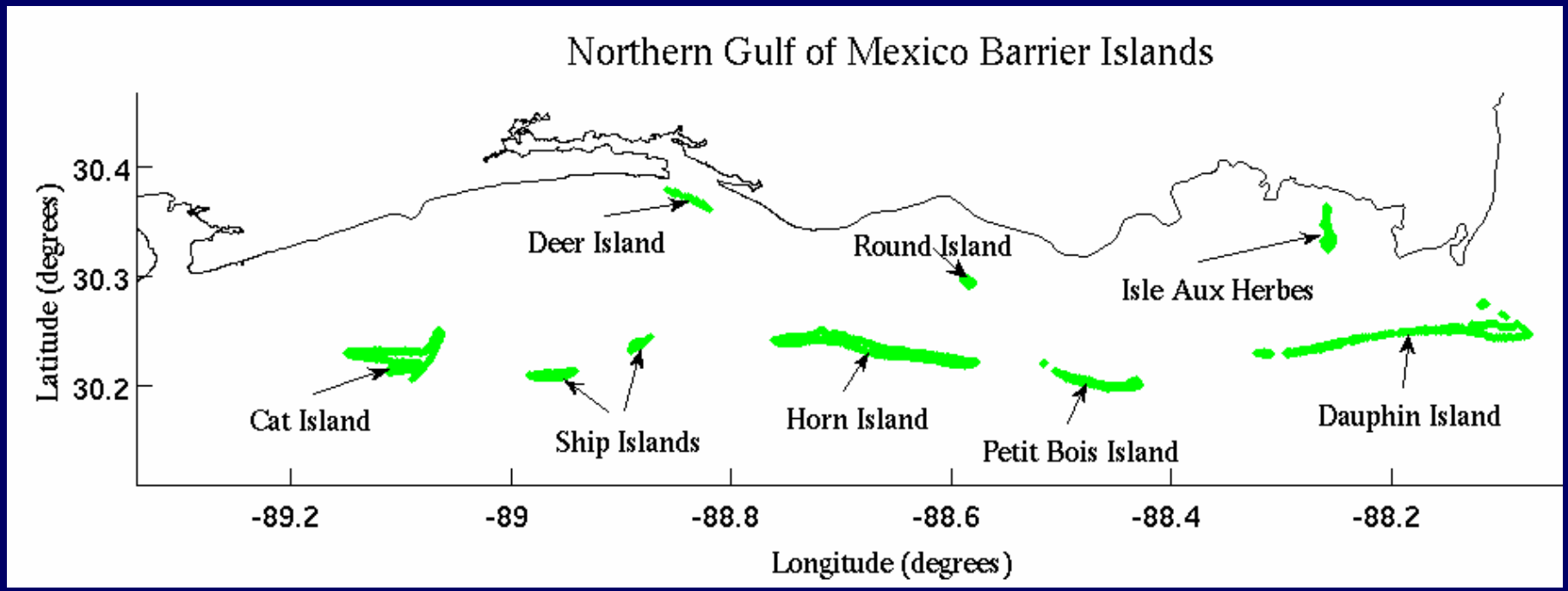
Goal:

Determine the predictability of storm surge

- how far in advance can we predict the outcome?
- what are the critical pieces of data?

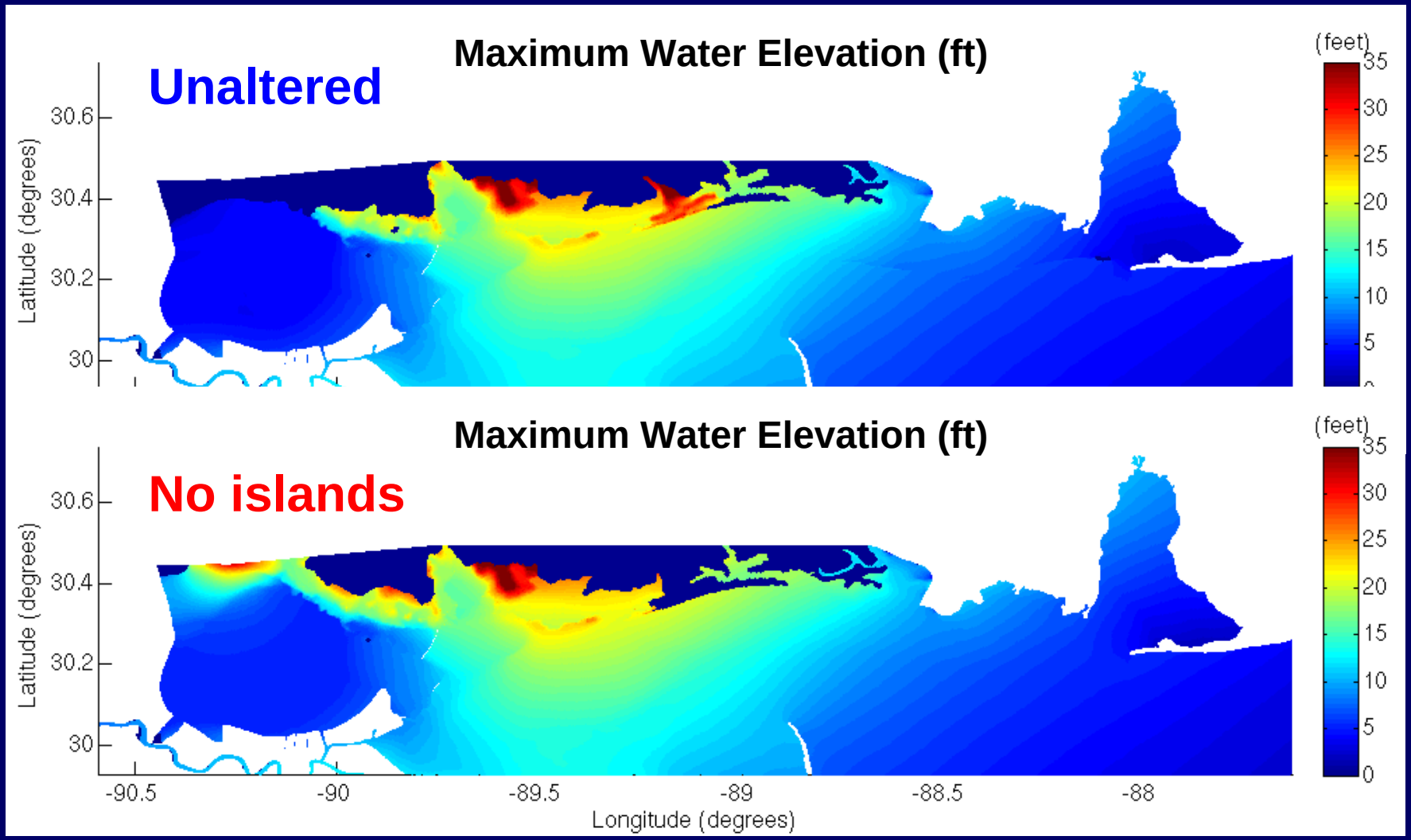
The Model as a Planning Tool

What is impact of islands on inundation?

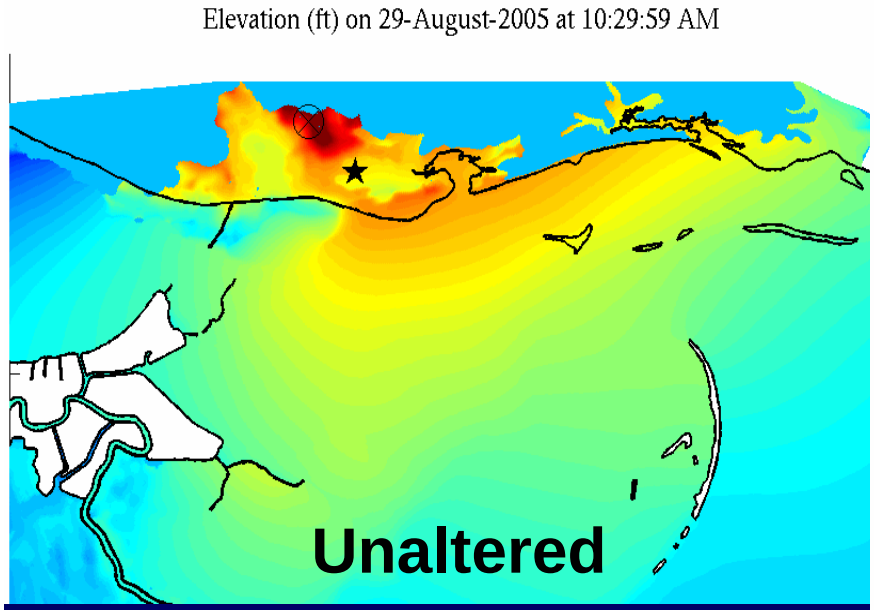


The Model as a Planning Tool

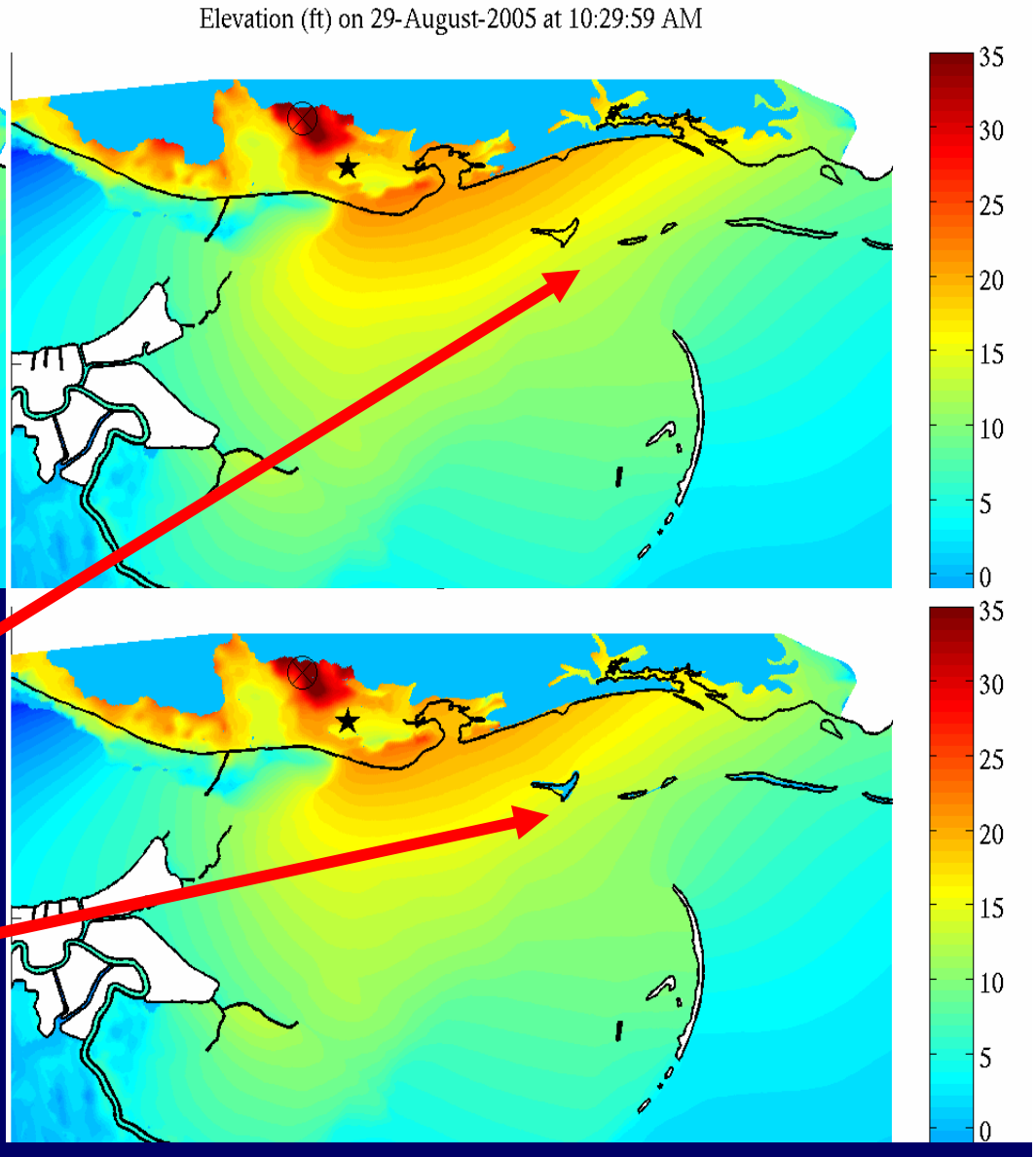
What is impact of islands on inundation?



The Model as a Planning Tool



Unaltered

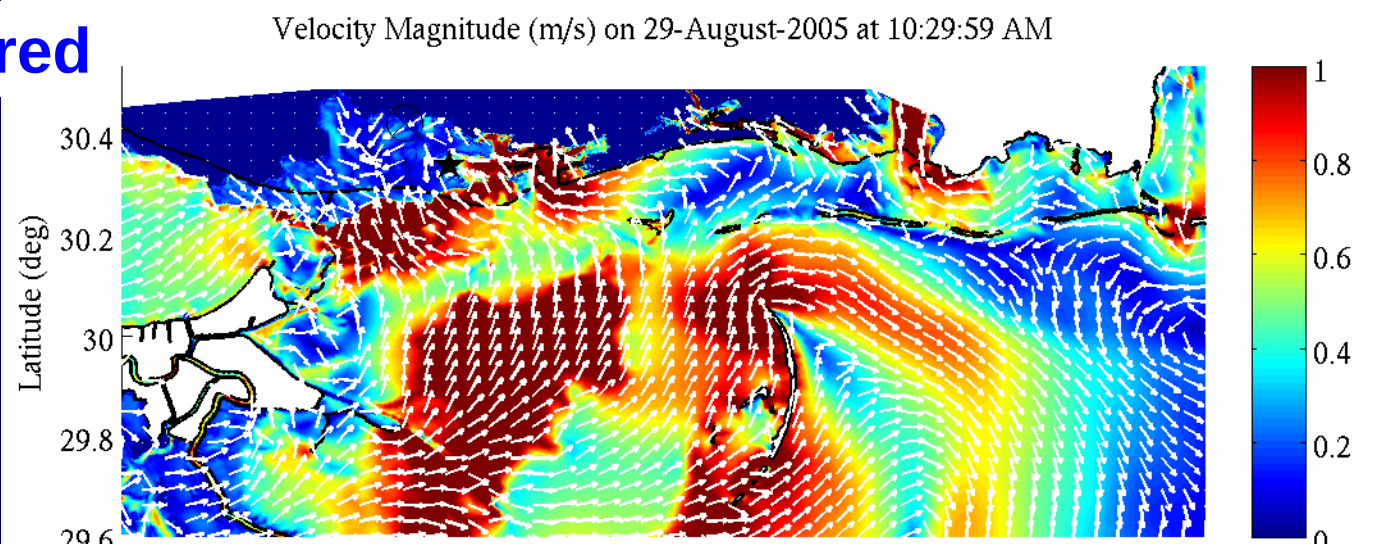


Islands **lowered** to surrounding water depths

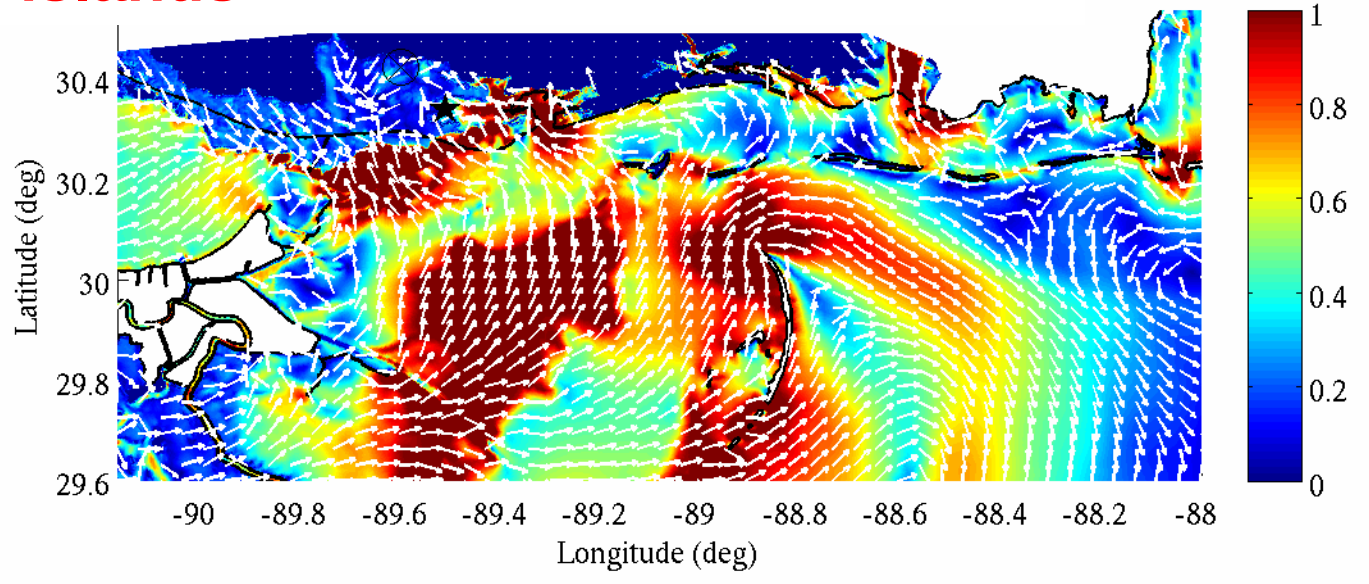
Islands **raised** to prevent overtopping

The Model as a Planning Tool

Unaltered



Raised islands



The Model as a Planning Tool

TO BE CONTINUED……..

Validation of the inundation prediction system and the quantification of factors that affect inundation extent and magnitude transfer to environments containing tidal flats and rivers.